UNITED STATES MARINE CORPS
MARINE CORPS BASE
QUANTICO, VIRGINIA 22134-5001

IN REPLY REFER TO:
6280
B 046
MAR 15 2001

Mr. Russell McAvoy, Jr., M.S., P.E.
Department of Environmental Quality
P.O. Box 10009
Richmond, Virginia 23240-0009

Dear Mr. McAvoy:

Please find enclosed two copies of the RCRA Closure/Post-Closure and Contingent Closure Plan for the Charlie Demo Open Burning/Open Detonation Site. This plan has been sent to formally request approval of the closure plan.

If you have any questions or require additional information, please contact Mr. Mark Branca, P.E. at (703) 784-4041.

Sincerely,

Bruce C. Frizzell

BRUCE C. FRIZZELL
Head, Natural Resources and
Environmental Affairs Branch
By direction of
the Commanding General

Enclosure: 1. Two Copies, RCRA Closure/Post-Closure and Contingent Closure Plan for the Charlie Demo Open Burning/Open Detonation Site

Copy to:
Ms. Stephanie M. Canfield, Commonwealth of Virginia, Department of Environmental Quality, Northern Regional Office, 13901 Crown Court, Woodbridge, VA 22193-1453 (with enclosure)

RCRA CLOSURE/POST-CLOSURE AND CONTINGENT CLOSURE PLAN FOR THE CHARLIE DEMO OPEN BURNING/OPEN DETONATION SITE

Marine Corps Combat
Development Command (MCCDC)
Quantico, Virginia
USEPA Identification No. VAD1170024722

Engineering Field Activity Chesapeake
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0299

February 2001

TETRA TECH NUS, INC.

RCRA CLOSURE/POST-CLOSURE AND CONTINGENT CLOSURE PLAN FOR THE CHARLIE DEMO OPEN BURNING/OPEN DETONATION SITE

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MARINE CORPS COMBAT DEVELOPMENT COMMAND
QUANTICO, VIRGINIA
USEPA IDENTIFICATION No. VAD1170024722

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Chesapeake
1314 Harwood Street, S.E.
Washington Navy Yard, D.C. 20374-5018

Submitted by:
Tetra Tech NUS, Inc.
600 Clark Avenue, Suite 3
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CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0299

FEBRUARY 2001

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ACRONYMS

ATSDR	Agency for Toxic Substances and Diseases Registry
CSF	Chronic Slope Factor
DoD	Department of Defense
EOD	Explosive Ordnance Disposal
HCOC	Hazardous Constituent of Concern
HEAST	Health Effects Assessment Summary Table
HI	Hazard Index
HQ	Hazard Quotient
IDW	Investigation-Derived Waste
IRIS	Integrated Risk Information System
MCCDC	Marine Corps Combat Development Command
MCL	Maximum Contaminant Level
OB/OD	Open Burning/Open Detonation
OSHA	Occupational Safety and Health Administration
PPE	Personnel Protection Equipment
PQL	Practical Quantitation Level
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
SHSP	Site Health and Safety Plan
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
USEPA	U.S. Environmental Protection Agency
UXO	Unexploded Ordnance
VADEQ	Virginia Department of Environmental Quality
VHWMR	Virginia Hazardous Waste Management Regulations

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Date: 3/15/01

Signature: Bruce C. Tuggell

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This Closure and Contingent Closure Plan (Closure Plan) has been prepared for the Resource Conservation and Recovery Act (RCRA) regulated open burning/open detonation (OB/OD) site at the Charlie (C)-Demo range at Marine Corps Combat Development Command (MCCDC) Quantico, Virginia. The purpose of this document is to facilitate a delay of closure for the C-Demo OB/OD site because it is located within an active military range. Although the C-Demo OB/OD site has not been used for the treatment of waste munitions since 1988, the continued long-term use of the C-Demo range for military training and testing activities is incompatible with final closure of the RCRA OB/OD site.

Preliminary sampling and analysis results for the C-Demo OB/OD site are presented in this Closure Plan that indicate that delay of closure would not endanger human health and the environment. Additional sampling will be conducted at the time of final closure as discussed in the Closure Plan.

MCCDC Quantico plans to use risk-based clean closure standards to achieve final closure of the C-Demo OB/OD site. However, the Closure Plan also includes a Contingent Closure Plan and Contingent Post-Closure Care Plan if closure with waste in place is necessary.

Although soil removal is anticipated to be the primary approach to achieve risk-based closure, the feasibility of alternative remediation technologies will be evaluated at final closure including (but not limited to) chemical stabilization and soil washing. These alternative remediation approaches would require an amendment to the Closure Plan, Contingent Closure Plan, and/or Contingent Post-Closure Care Plan.

1.2 FACILITY POINT OF CONTACT

The point of contact for the Closure Plan for the C-Demo OB/OD site is as follows:

Point of Contact:	NREA Branch (BO46)
Address:	3250 Catlin Avenue
	Quantico, VA
Telephone No.:	703-784-4041

The facility copy of the Closure Plan will be kept on file at the above-referenced location.

1.3 APPLICABLE REGULATIONS

This Closure Plan has been prepared to meet the requirements of Title 9 – Environment of the Virginia Administrative Code (VAC) 20 – Virginia Waste Management, Chapter 60 – Virginia Hazardous Waste Management Regulations (VHWMR) as applicable to the closure of miscellaneous units (i.e., the C-Demo OB/OD site). The C-Demo OB/OD site did not receive interim status and has been inactive (regarding RCRA-regulated OB/OD treatment of waste munitions) since 1988. The closure requirements for miscellaneous units are included in 9 VAC 20-60-264 (adoption of 40 CFR 264 by reference). The requirements for closure of miscellaneous units are specified in 40 CFR 264.600-603 (Subpart X). The Closure Plan is consistent with the requirements for 40 CFR Subpart X. The Closure Plan is also consistent with requirements for 40 CFR 264.110-120 (Subpart G) of 9 VAC 20-60-264 and 40 CFR 265.110-120 (Subpart G) of 9 VAC 20-60-265.

1.4 CLOSURE PERFORMANCE STANDARDS

During the delay of closure period the C-Demo OB/OD unit will not endanger human health and the environment (see Section 3.4). At final closure the C-Demo OB/OD site will be closed in a manner that:

- Minimizes the need for further maintenance;
- Controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere; and
- Complies with applicable VHWMR closure requirements.

Risk-based clean closure standards will be used for the final closure of the C-Demo OB/OD site. However, if clean closure cannot be achieved then closure with waste in place will be implemented commensurate with the Contingent Closure Plan and Contingent Post-Closure Care Plan.

2.0 SITE DESCRIPTION

2.1 LOCATION

The MCCDC Quantico installation is located approximately 35 miles south of Washington, D.C., and approximately 75 miles north of Richmond, Virginia (Figure 2-1). The installation includes approximately 60,000 acres and lies within Prince William, Stafford, and Fauquier Counties. The installation is bounded to the north by Cedar Run and Virginia State Route 646; to the east by the Potomac River; to the south by Tank Creek, Aquia Creek, and Virginia State Route 610; and to the west by Darrel's Run and Virginia State Route 612. The Base is divided into two sections: the Mainside Area, which is located to the east of Interstate 95, and the combined training areas (Guad Area, which is located to the west of I-95) (Figure 2-2).

The location of the C-Demo OB/OD site at the MCCDC at Quantico is illustrated in Figure 2-3. The C-Demo OB/OD site represents only a portion of the C-Demo Area. The C-Demo area is comprised of approximately 80 acres of cleared terrain characterized by three mounds (e.g., topographic highs) as shown on Figure 2.4.

2.2 HISTORICAL AND FUTURE OPERATIONS

All three mounds at C-Demo have been used for OB or OD of ordnance and related types of activities. The middle and north mounds are reported to have been only used for experimental and training type of demolition activities and thus, by definition, are exempt from RCRA and VHWMR regulations. This Closure Plan is, therefore, limited to a portion of the south mound that was constructed in 1975 and used for waste munition treatment and military operations until 1988. For the remainder of this Closure Plan the C-Demo OB/OD site refers only to the portion of south mound shown Figure 2-4.

The south mound, according to available information, was used for OB/OD of waste explosives and propellants. Activities were conducted in pits and trenches that were subsequently backfilled with previously excavated soil. Pits used for OD ranged in size from 10 feet in diameter by 5 feet in depth to 20 feet in diameter by 12 feet in depth. Trenches used for OB were approximately 35 to 40 feet long, 10 feet wide, and 5 feet deep. Small arms handled at the site were all less than 50 caliber. Based on the available historical information, the potential exists for unexploded munitions (although unlikely), exploded munitions products, burn residues, metals fragments, and possibly kerosene constituents (although unlikely).

The OB/OD treatment of waste munitions at C-Demo was terminated in 1988. However, MCCDC Quantico plans to continue use of the south mound (as well as other areas at C-Demo) for various military training, testing, and evaluation purposes. Near term uses for the C-Demo OB/OD site include:

- Department of Defense (DoD) EOD units and Federal Law Enforcement agencies technical training using explosives and explosively actuated tools.
- Striping and inerting of explosive ordnance for training and research and development projects.
- Demonstrations of force protection equipment and explosive effect for members of the White House Staff and senior government officials.
- Suspect cargo staging area location.

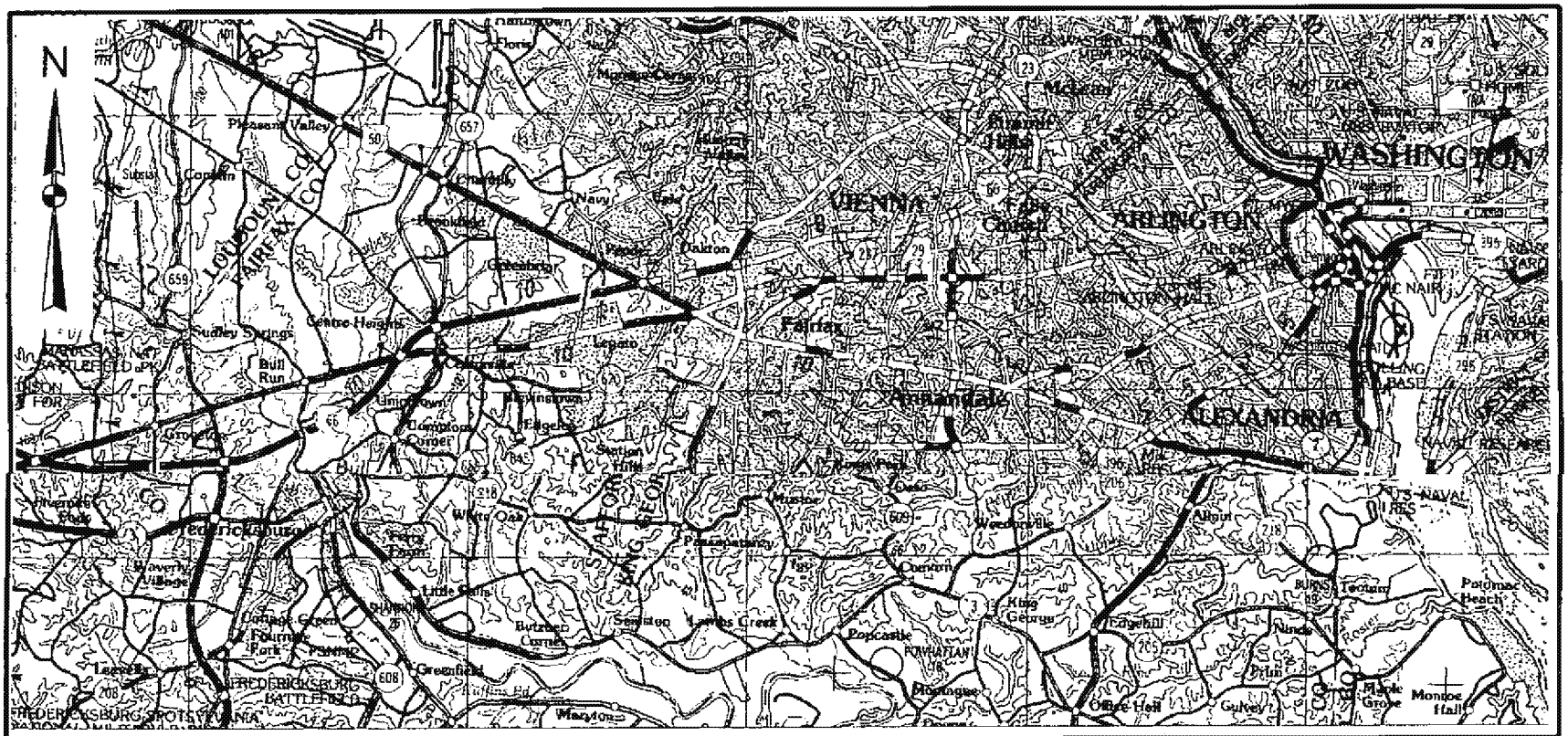
Specific MCCDC plans for future use of this active range may vary based on changes in national defense needs. These active range military activities at the C-Demo area are RCRA-exempt pursuant to the Military Munitions Rules. Final closure of the OB/OD site will be conducted when the C-Demo area (range) is closed, transferred, or transferring.

2.3 TOPOGRAPHY

Topography in the vicinity of the C-Demo site is generally characterized by gently rolling hills. The land surface slopes gently to the southeast at an average of 20 feet per mile. MCCDC Quantico is located on the Fall Line, the boundary between the Piedmont and the Atlantic Coastal Plain physiographic provinces. The Fall Line in Virginia trends northeast-southwest and is located approximately 4 miles west of I-95 in the project area.

To the west of the Fall Line, the Piedmont province is characterized by moderately dissected, rolling hills that generally slope from a maximum elevation of 600 feet above the mean sea level (msl) on its western flank to approximately 250 feet above msl at the Fall Line.

The C-Demo OB/OD site located on a topographic high approximately 270 feet above msl as illustrated in Figure 2-5.



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COST/SCHEDULE-AREA		APPROVED BY — DATE	
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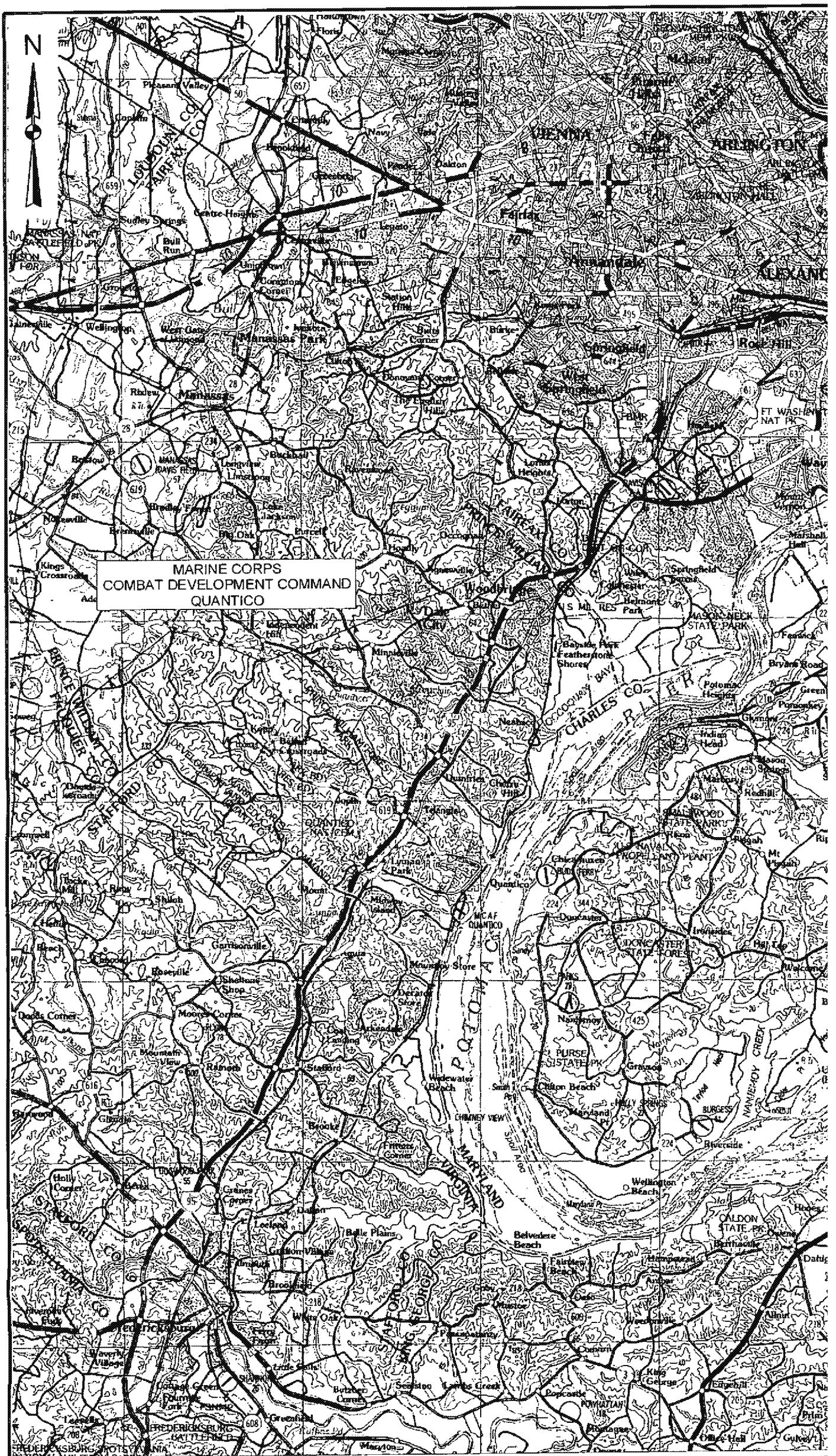

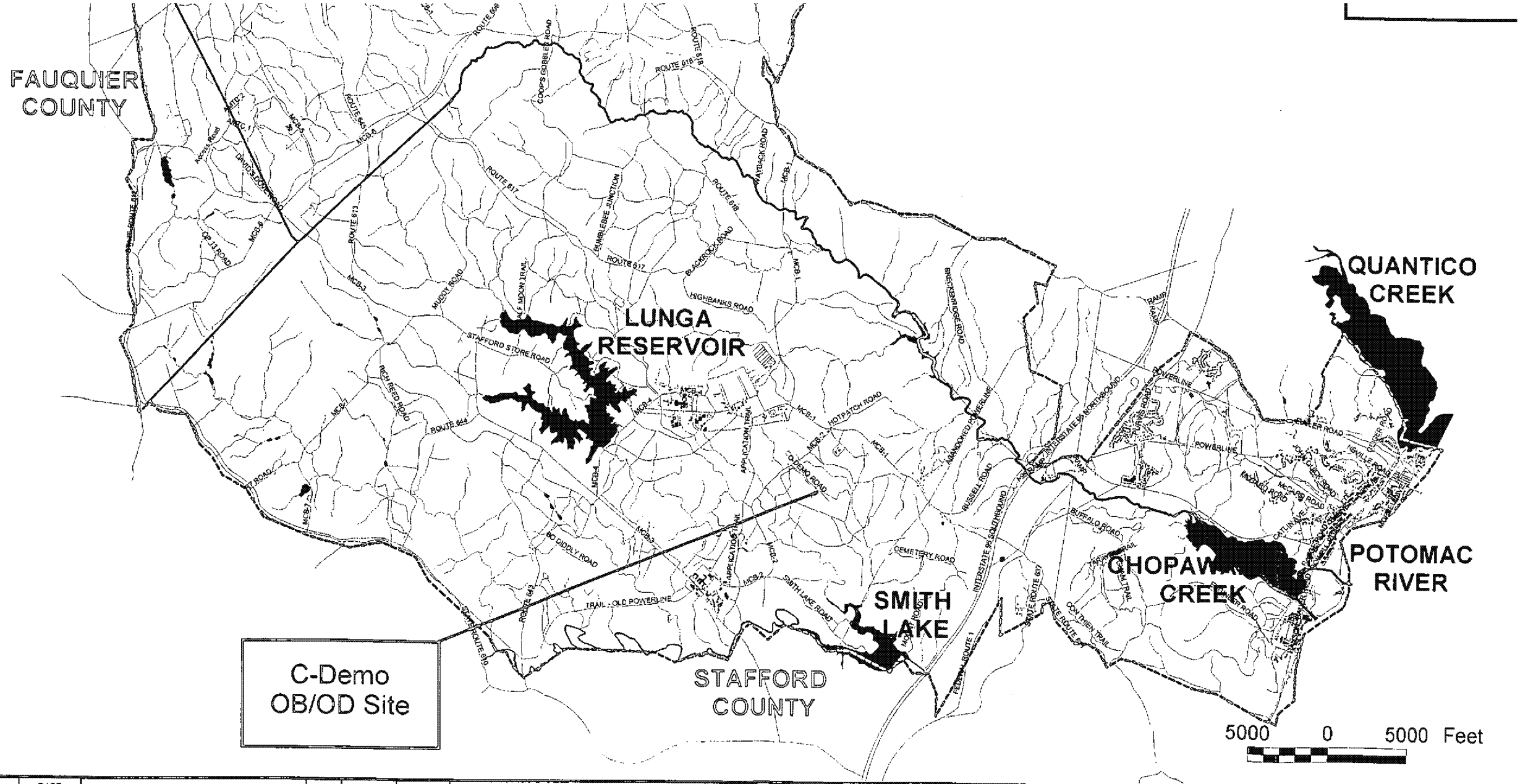

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DRAWN BY CSP DATE 06/14/00

CHECKED BY mm DATE 09/13/00

COST/SCHEDULE-AREA

SCALE AS NOTED

Tetra Tech NUS, Inc.

Basewide Site Map
C-Demo OB/OD Site
MCCDC, Quantico, Virginia

CONTRACT NUMBER 7692 | OWNER 810

APPROVED BY | DATE

APPROVED BY | DATE

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FIGURE 2-2

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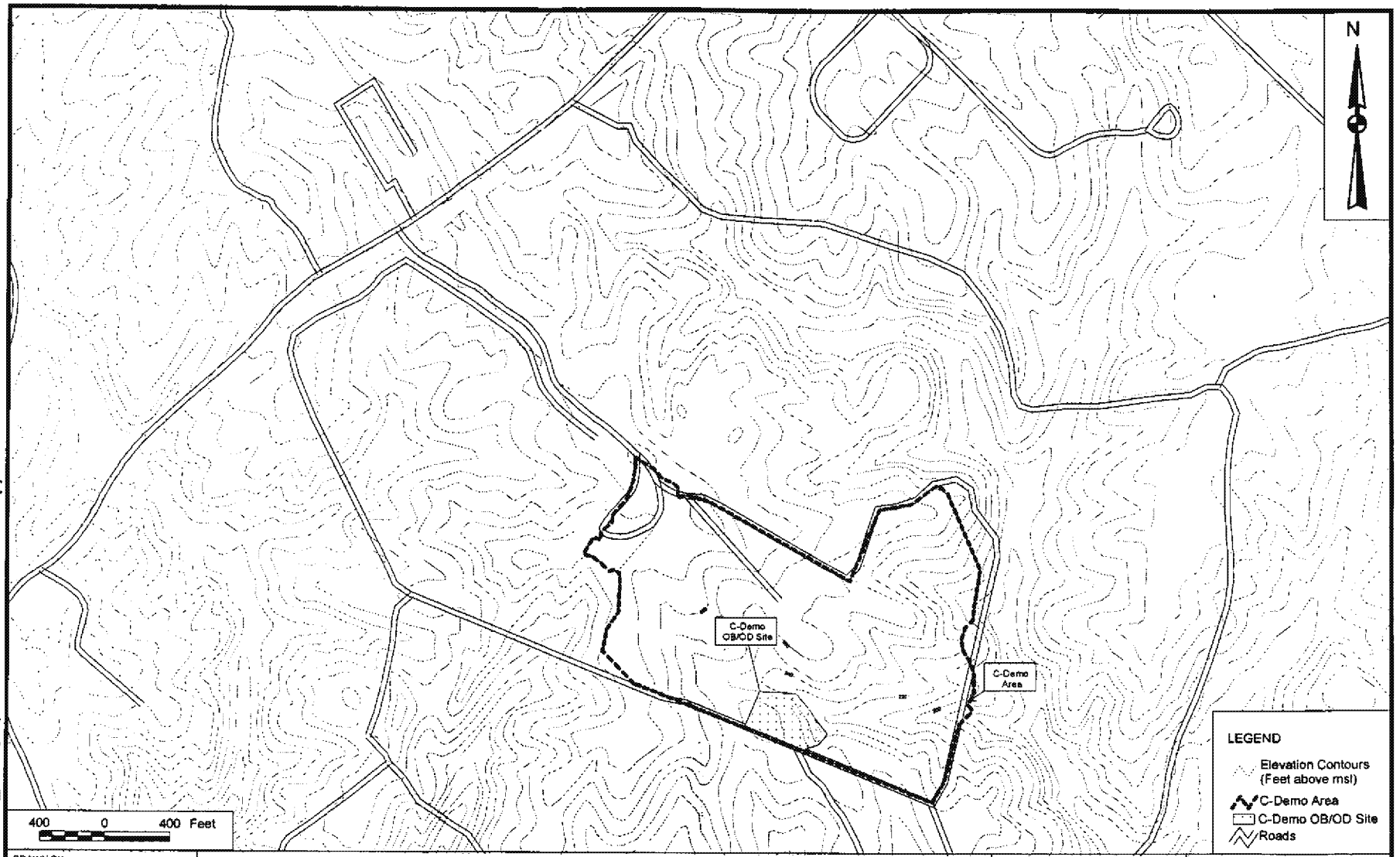

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LEGEND
Elevation Contours (Feet above msl)
C-Demo Area
C-Demo OB/OD Site
Roads
C-Demo Area
MOUND 3
MOUND 2
MOUND 1
C-Demo OB/OD Site
720
280
240
200
400
0
400 Feet
Tetra Tech NUS, Inc.
C-Demo OB/OD Site Diagram
MCCDC Quantico, Virginia
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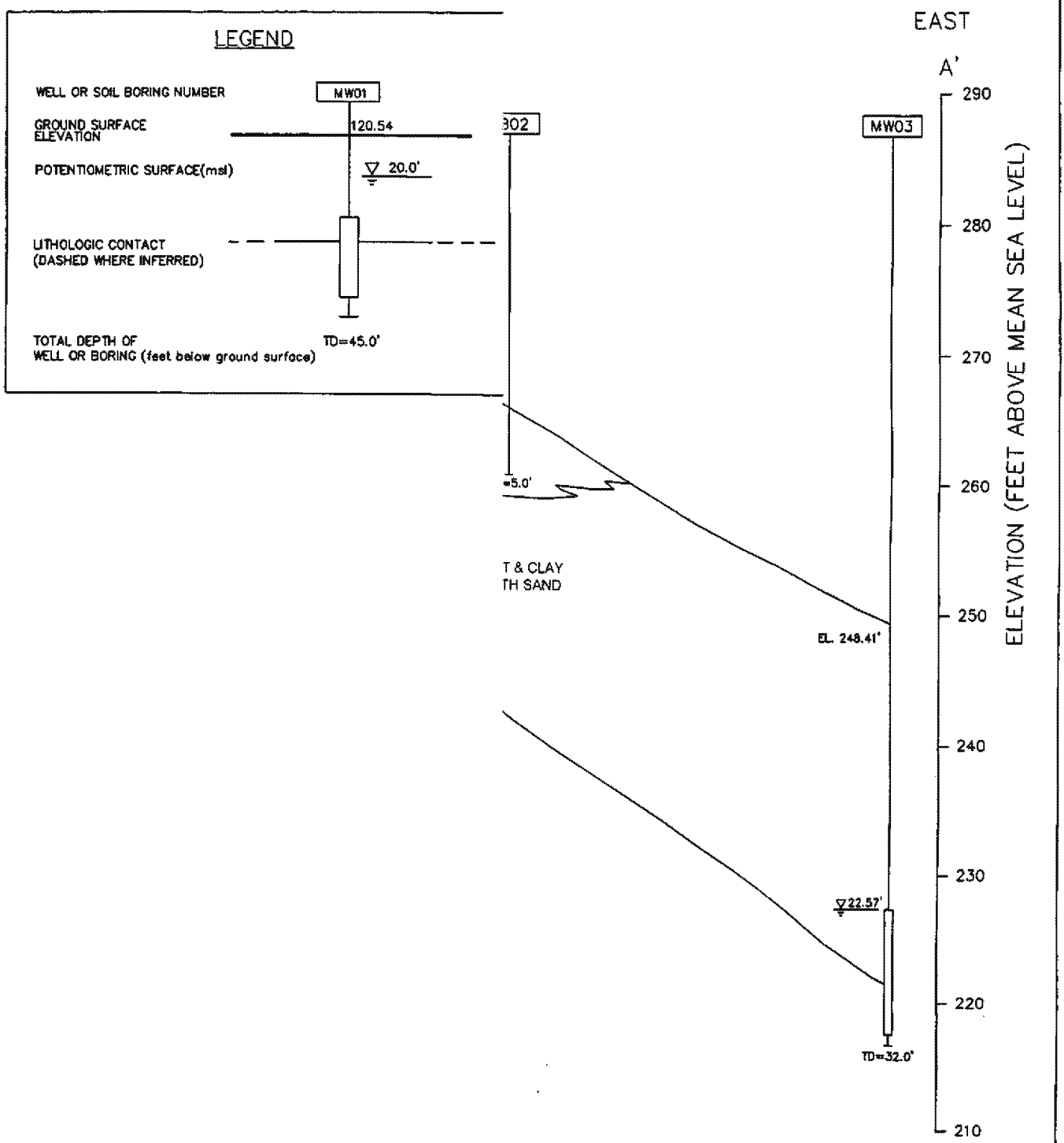

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2.4 HYDROGEOLOGICAL SETTING

Site geology was determined from the five soil borings and three monitoring wells that were drilled (1991) at the C-Demo OB/OD site. The lithology in the area of the site can generally be described as a mixture of silts and clay with traces of fine sand and gravel throughout. It appears that reworked original material of the mound, due to site operations, ranged from the surface to an 8-foot depth. This is illustrated by the cross section of Figure 2-5. One of the soil borings (SB05) was advanced to the top of bedrock that was encountered at about 21 feet. Bedrock consisted of a decomposed schist and was also encountered in the three monitoring wells at depths ranging from 15 feet to 28 feet. Groundwater flows in a southeast direction, as shown in the potentiometric contour map of Figure 2-6.

2.5 SURFACE WATER

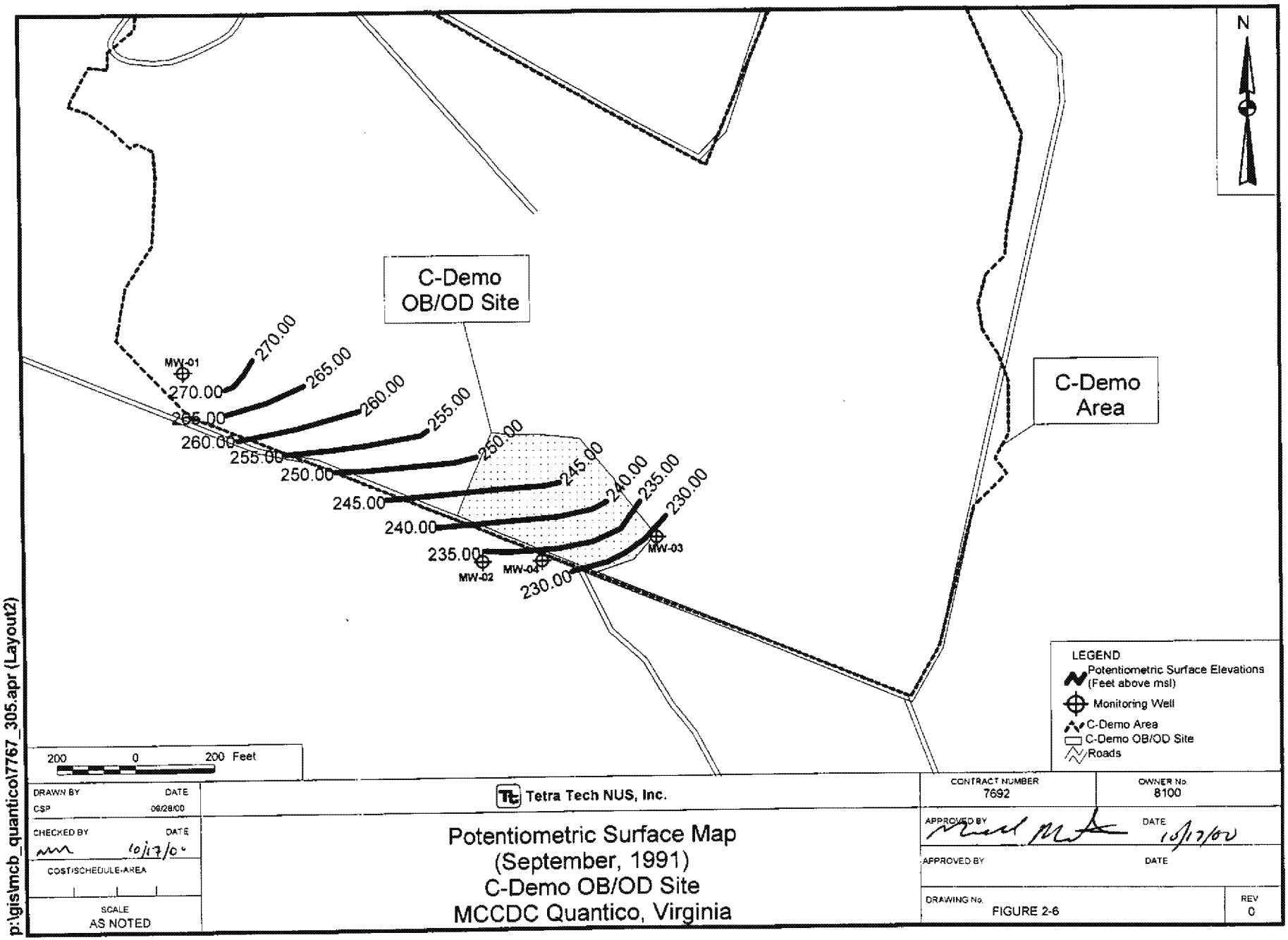
MCCDC Quantico has numerous surface water drainage systems that generally flow to the east and southeast, and eventually empty into the Potomac River. The drainage systems on MCCDC Quantico can be subdivided into six major watersheds: Quantico Creek, Cedar Run, Aquia Creek, Chopawamsic Creek, Tank Creek, and Little Creek.

Drainage systems in the Piedmont province generally have streams that flow swiftly where the soils are thin and bedrock materials are often found at or just below stream bottoms. Once streams cross to the east of I-95 and enter the Coastal Plain province, they generally become wider and slower. This change is evidenced by the large estuaries, tidal flats, and marsh areas that exist east of I-95. It is likely that local shallow groundwater flow systems discharge to the surface water bodies in these marsh areas.

Drainage from the C-Demo OB/OD site is expected to flow into Smith Lake (e.g., Aquia Reservoir). Some local swales in the vicinity of the site may occasionally have some standing water. The C-Demo OB/OD site is not within any 100-year flood impact zone.

2.6 CLIMATOLOGICAL SETTING

The climate for the region is classified as a temperate humid climate with mild winters, hot summers, and no distinct dry season. Mean temperature ranges from a monthly maximum of about 77°F in July to a monthly minimum of about 37°F in January. The annual prevailing winds for the region are from the south or south-southwest at a velocity of approximately 9 miles per hour, except for the winter months when a northwesterly wind prevails. The mean annual precipitation is approximately 40 inches.



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3.0 WASTE CHARACTERIZATION

3.1 WASTE MUNITIONS

The C-Demo OB/OD site was used for the thermal treatment of a wide variety of conventional waste munitions. Potential items treated include the following munition categories.

- Small arms, fuzes, and primers
- Smokes and dyes
- Pyrotechnics
- High-explosive-loaded projectiles
- Risk control agents
- Grenades and mines
- Navy gun ammunition
- Special function projectiles (e.g., submunitions)
- Propellant charges

Chemical munitions possibly treated at this facility were limited to:

- White phosphorus
- Red Phosphorus
- CS - "Pepper"
- HC - "Obscuring Smoke"

Munitions containing depleted uranium were not treated at the C-Demo OB/OD site.

Primary constituents of conventional waste munitions include the following:

- Energetics
- Metals
- Trace constituents

Table 3-1 presents a summary of the chemical composition of typical waste munitions items treated at the C-Demo OB/OD site.

TABLE 3-1

EXAMPLE CHEMICAL CONSTITUENTS OF ENERGETICS TREATED AT THE CHARLIE DEMO OB/OD SITE MCCDC, QUANTICO, VIRGINIA

Hazardous Material	General Hazardous Constituents
Composition B (60/40 Cyclotol)	RDX 60% TNT 30% Wax 1%
Yellow or Red Smoke Grenades	Lead compounds 0.1% Organic dye 11.11%-31.3% Dextrin 2.76%-5.41% Benzanthrone 0.24.44% Sulfur 8.44%-12.36% Potassium Chlorate 20.00%-31.9% Sodium Bicarbonate 16.5%-32.92% Barium compounds 0.24% RDX 0.26% Potassium Perchlorate 0.06% Nickel Powder 0.06% Nitrocellulose 0%-1.93%
Illumination Mix	Magnesium Sodium Nitrate Binder Various metals
Thermite	Ferric oxide Powdered aluminum
Black Powder	Potassium nitrate 74.0% Charcoal 15.6% Sulfur 10.4%
Pyrotechnics	Oxygen or fluorine oxidizing agents; powdered aluminum and magnesium fuels
Small Arms	Nitrocellulose
Photo Flash	Laminax 96.8% Lupersol 3.0% Iron oxide 0.2%
TNT	Trinitrotoluene
50/50 Pentolite	PETN 50.0% TNT 50.0%
Nitrogel	200-25% nitroglycerin gelatinized with colllodion cotton, ammonium nitrate, and a liquid aromatic nitrocompound serving as a sensitizer
PETN	Pentaerythrite tetranitrate
RDX (Cyclonite)	Cyclotrimethylene-trinitramine
HC Grenades	Hexachloroethane 44.9% Lead compounds 0.06% Zinc oxide 47.9% Aluminum Powder 6.97% Magnesium Powder 0.05%

3.2 OB/OD EMISSIONS

Potential OB/OD emissions can be summarized as follows:

- Primary emissions
  - + Carbon dioxide
  - + Nitrogen
  - + Water vapor
- Secondary emissions
  - + Nitrogen dioxide
  - + Nitrogen oxide
  - + Carbon monoxide
  - + Particulates
- Potential trace emissions
  - + Energetics
  - + Other semivolatiles
  - + Metals
  - + Sulfides
  - + Cyanide
  - + Chlorides
  - + Nitrates/nitrates
  - + Volatile organics
  - + Dioxins/furans

Based on OB/OD emissions characterization tests conducted by the U.S. Army, the U.S. Environmental Protection Agency (USEPA) has concluded that most OB/OD emissions can be adequately represented by the following analytes (USEPA, August 1998):

- Carbon dioxide/carbon monoxide
- Nitrogen dioxide/nitrogen oxide
- Saturated hydrocarbons (e.g., ethane, propane, butane)
- Acetylene, ethylene, and propane

- Benzene
- Toluene
- Particulates

Proposed target analytes (based on waste munition composition and OB/OD emissions information) for the sampling program at final closure are identified in Appendix D. These target analytes listed in Appendix D represent potential hazardous constituents of concern (HCOCs) for closure of the C-Demo OB/OD site.

3.3 MAXIMUM WASTE INVENTORY

The maximum inventory of waste munitions treated during the active life of the C-Demo OB/OD treatment site cannot accurately be determined. Records of disposal actions are incomplete and the amount and type of munitions treated were dependent on many factors including:

- Misfire rate of ordnance.
- End use of misfired ordnance. Not all ordnance was destroyed. Some items were sent for rework while some items were used for other training missions.
- Amounts of ordnance used and frequency of training.

The start-up date for OB/OD treatment activities at C-Demo is not known but activities ceased in 1988 as a result of a Compliance Evaluation Inspection in January of that year. Waste munitions were not stored or accumulated at the OB/OD site. Therefore, the maximum onsite inventory of most munitions corresponds to the maximum treatment event. (However, as noted above OB/OD treatment records are incomplete). Waste materials were transported to the site on the day of treatment and treated upon arrival. No untreated munitions remain at the site. Although the C-Demo OB/OD site has been routinely cleared, there is the potential for the presence of some UXO, munition components, and shrapnel.

It is not possible at this time to accurately estimate the quantity of soil that may require removal at final closure (based on risk-based clean closure standards) or the nature of the wastes (if any) that may be generated during closure activities. However, based on the 1991 preliminary site investigation Toxicity Characteristic Leaching Procedure (TCLP) results for lead, the volume of soil for removal is estimated to be less than 100 cubic yards.

The sampling and analysis activities described in Section 4.4 and 4.5 of this Closure Plan will facilitate (at final closure) the characterization of the extent of contamination of the OB/OD site and identify the need for any soil excavation and removal. An accurate estimate of the quantity of solid and hazardous waste requiring remediation will be provided to VADEQ upon completion of this site investigation. Wastes generated during any remedial activities may consist of contaminated soils and items, such as UXO, munition components, and metallic shrapnel (these wastes may have been generated by past OB/OD treatment activities or military training and testing activities at the C-Demo range). Information on the methods for removing, transporting, storing, and disposing of closure wastes is provided in Section 4.6 – 4.9 of this Closure Plan.

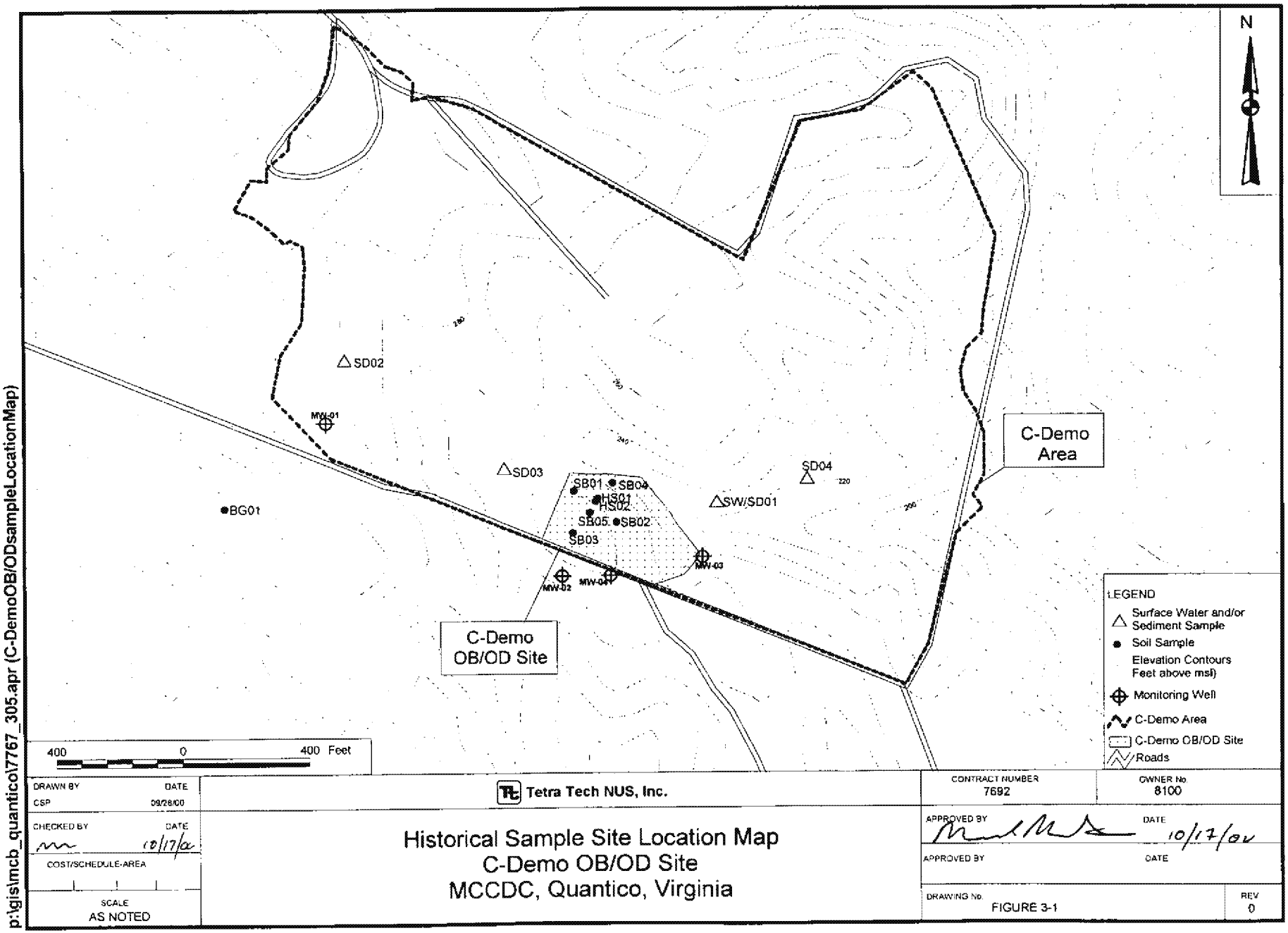
Based on preliminary sampling results for the C-Demo OB/OD site only limited "hot spot" areas within the site are expected to require soil removal.

3.4 PRELIMINARY CHARACTERIZATION INVESTIGATION RESULTS

A preliminary characterization investigation was conducted at the C-Demo OB/OD site in 1991. The objective of this investigation was to characterize the nature and extent of contamination (if any) at the site to support preparation of Closure Plan documents. The investigation included the following (refer to Figure 3-1):

- Five soil borings at the mound and one background boring (surface to a maximum of 21.5 feet).
- Two downgradient and one upgradient groundwater monitoring wells (a third downgradient well was installed but not sampled).
- One surface water sample (i.e., from a downgradient swale).
- Four sediment samples (nearby surface water drainage swale).

The primary target analytes for these environmental samples were energetics and Target Analyte List (TAL) metals. Three soil samples, including two suspected hot spots, were analyzed for total petroleum hydrocarbons (due to the possibility of kerosene use on site) and total organic carbon. The potential hot spot soil samples were also subject to TCLP extraction procedures and the resulting leachate was subsequently analyzed for TAL metals.



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Analytical data for the 1991 preliminary investigation are provided in Appendix A and boring logs/well construction diagrams in Appendix B.

The 1991 sampling results have been evaluated using the most current USEPA Region III risk-based concentrations (RBCs) (April 13, 2000). Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and VADEQ Alternative Concentration Limits (ACLs) (VADEQ, 1999) as appropriate. These screening criteria include the following:

- Soil reference concentrations (used to evaluate soil and sediment samples)
  - + USEPA Region III RBCs for Industrial exposures (conservative for current and future military training activities at the site)
  - + USEPA Region III RBCs for Residential exposures (used for comparative purposes only)

- USEPA Region III Soil screening levels (i.e., potential to migrate to groundwater)
  - + Dilution attenuation factor (DAF) of 1 applicable to sites with shallow water tables or source size greater than 30 acres.
  - + DAF of 20 applicable as a default value for other site conditions.

- Drinking water screening values (used to evaluate groundwater and surface water). Drinking water criteria selection was based generally on the hierarchy followed by VADEQ for establishing Groundwater Protection Standards in RCRA permits. The following criteria were considered in descending order as available for individual constituents.
  - + SDWA MCLs
  - + VADEQ ACLs
  - + USEPA Region III RBCs for Tap Water Ingestion

Industrial human health soil screening criteria are currently appropriate for the C-Demo OB/OD site because military training activities will continue at this location. Groundwater depth at the site ranges from 24 to 32 feet and the source area is only about 4 acres. Thus, the appropriate soil screening levels (relative to potential migration from soil to groundwater) are within the range of values presented for DAF 1 and 20 site conditions. TCLP standards were also used to evaluate the leaching potential of soil hot spot areas.

A comparison of the 1991 sampling data results with the referenced screening criteria is provided in Appendix C. A summary of these results is presented in Table 3-2 and as follows:

- 2,4-DNT exceeded the soil screening levels (for both DAF 1 and 20) based on potential for migration from soil to groundwater. But 2,4-DNT was not detected in the groundwater samples. Therefore, 2,4-DNT is considered a potential HCOC for the C-Demo OB/OD site.

- Arsenic basewide background for soils exceed human health screening criteria. Arsenic soil and sediment samples from the C-Demo OB/OD site also exceeded screening criteria but groundwater and surface water results did not exceed drinking water criteria. Thus, arsenic is considered a potential HCOC for this site.

- Barium, cadmium, chromium, and silver soil samples exceeded potential migration to groundwater soil screening levels. However, groundwater and surface water sample results for these constituents were less than the drinking water screening criteria. Therefore, these constituents are considered as potential HCOCs for the C-Demo OB/OD site.

- Basewide soil background as well as samples at the C-Demo OB/OD site for iron exceeded residential (but not industrial) risk-based screening criterion for soils. However, only the industrial criterion is applicable at this military training site.

  Manganese downgradient, unfiltered groundwater results exceeded drinking water screening criteria. But filtered groundwater samples did not exceed screening criteria for this constituent. Therefore, the migration potential for iron is minimal based on groundwater data and for manganese based on the significant difference between filtered versus unfiltered groundwater results. They are considered potential HCOCs for the C-Demo OB/OD site.

- The residential risk-based soil screening criterion (based on supplemental USEPA Region 9 Preliminary Remediation Goals) for lead was exceeded but confined to limited subareas. However, the industrial screening criterion for lead in soil (applicable to the site based on use for military training) was not exceeded. Although the TCLP lead results for some limited soil subareas exceeded the RCRA toxicity characteristic criterion for classification of hazardous waste, (lead concentrations from groundwater surface

TABLE 3-2

EVALUATION OF MAXIMUM SAMPLING RESULTS APRIL 2000 USEPA REGION III RISK-BASED CONCENTRATIONS AND RCRA TCLP STANDARDS MCCDC, QUANTICO, VIRGINIA

Contaminants That Exceeded Screening Criteria	Soil						Groundwater		Surface Water	Sediment			
		Risk-Based Concentration		Soil Screening Level (Migration to GW)						Risk-Based Concentration		Soil Screening Level (Migration to GW)	
	Greater Than Basewide Background[1]	Industrial	Residential (not applicable to C-Demo)	DAF-1	DAF-20	TCLP	Greater Than Upgradient Well	Drinking Water Criteria	Drinking Water Criteria	Industrial	Residential (not applicable to C-Demo)	DAF-1	DAF-20
Energetics													
2,4 DNT	INA			✓	✓	NA							
Inorganics													
Arsenic		✓[2]	✓[2]	✓	✓						✓[2]	✓	✓
Barium	✓			✓[3]									
Cadmium	✓			✓									
Chromium				✓[3,4]	✓[4]							✓[4]	✓[4]
Iron			✓[3]										
Lead	✓		✓			✓							
Manganese							✓	✓[5]	✓				
Silver	✓			✓									

✓ = Exceedance of screening criteria.
INA = Information not available.
NA = Not applicable.

1 Basewide Background Report, MCCDC, Quantico, Virginia, April 2000.
2 Basewide background for arsenic also exceeded soil human health screening criteria.
3 Exceedence of background sample also.
4 Exceedence for chromium VI only.
5 Exceedence for unfiltered samples only.

water, and sediment samples were acceptable indicating that infiltration to groundwater or overland transport is not significant. Therefore, for conservatism lead is a potential HCOC for this site that will be further evaluated at final closure but is not a hazard during the delay of closure period.

In summary, lead is the primary HCOC relevant to the final closure for the C-Demo OB/OD site. Some potential hot spots of lead (based on the TCLP criterion) may be considered as hazardous wastes potentially requiring remediation or installation of a landfill cap at the time of closure. However, lead concentrations in the soil have not impacted groundwater or surface water quality acceptability at the site. In addition, sediment data indicates overload transport is not a significant migration pathway.

Based on the consideration discussed in this section it can be concluded that delay of closure of the C-Demo OB/OD site can be accomplished without endangerment to human health and the environment (because no significant onsite contamination source exists and the potential for offsite migration at concentrations of concern is minimal).

4.0 CLOSURE PROCEDURES

4.1 CLOSURE OVERVIEW

The following measures will be implemented at the C-Demo OB/OD site during the delay of closure period:

- Maintenance of a vegetation cover to mitigate the potential for overland runoff.
- Routine mowing of the vegetation cover to facilitate identification of surface UXO.
- Routine surface UXO clearance commensurate with future range use (i.e., military training and testing activities).
- Close/abandon the four monitoring wells at mound (1) prior to resuming training in that area.

Procedures for final closure of the site have been summarized below in steps. A detailed description of each step is provided in Sections 4.2-4.9.

- Step 1 – Develop and implement a Site Health and Safety Plan (Section 4.2).
- Step 2 – Mobilization and site preparation (Section 4.3).
- Step 3 – Conduct a sampling and analysis program to characterize the nature and extent of contamination (Section 4.4).
- Step 4 – Statistically evaluate the sampling and analysis data and develop risk-based closure standards (Section 4.5).
- Step 5 – Subsurface UXO clearance (Section 4.6).
- Step 6 – Excavation of contamination soil and restoration of the disturbed area (Section 4.7)

- Step 7 – Decontamination of personnel and equipment (Section 4.8)
- Step 8 – Waste analysis and disposal (Section 4.9)
- Step 9 – Submit certification of closure (Section 5.1) and closure report (Section 5.2)

The closure schedule is presented in Section 5.3. If closure conditions warrant, an amendment to this Closure Plan would be prepared and submitted to VADEQ (see Section 5.4). However, if clean closure cannot be achieved, the Contingent Closure Plan (Section 8.0) and Contingent Post-Closure Care Plan (Section 9.0) would be implemented.

4.2 SITE HEALTH AND SAFETY PLAN

Before initiating the closure activities, a site-specific Site Health and Safety Plan (SHSP) will be developed commensurate with the requirements of Occupational Safety and Health Administration (OSHA) 29 CFR 1910.120, which outlines procedures to be taken to protect the health and safety of the general public and persons involved with the closure activities. The plan will be prepared and administered so that individuals participating in the closure activities will be knowledgeable of the potential hazards and specific safety precautions required. Development, implementation, and enforcement of the SHSP will be the responsibility of the contractor performing the closure activities. All personnel participating in closure activities will be properly trained in accordance with the OSHA Hazardous Waste Operations and Emergency Response training program.

The SHSP will designate a qualified Site Health and Safety Officer to ensure that all persons are in compliance with the required procedures of the SHSP. The plan will include notification of local fire, safety, and health response organizations, including MCCDC Quantico Explosive Ordnance Disposal (EOD) personnel, before starting the work and in the event of an emergency during the closure operations. The plan shall include site security procedures to prevent unauthorized entry into the controlled remediation area until closure is complete. It will define the level of personal protective equipment (PPE) required for persons involved in the remediation work area and for persons required to enter the controlled remediation area. The plan will also define the methods of monitoring atmospheric contamination and worker exposure levels. Finally, it will outline procedures and methods for worker and equipment decontamination. The SSHP will be developed in accordance with all applicable USEPA and OSHA regulations and guidelines for worker protection as well as all Department of Defense explosive

ordnance requirements. The following list discusses topics that, at a minimum, will be included in the SSHP Plan:

- A controlled work area barrier will be constructed and posted to prevent unauthorized entry.
- Local fire, safety, health, and EOD representatives will be contacted and informed of the scope of work before starting closure activities.
- A single entry control point will be established where all persons and equipment shall enter and exit the controlled work area, and where appropriate decontamination operations will be performed.
- All persons entering the controlled work area will be equipped with the proper PPE.
- All UXO safety, and management disposal operations will be conducted using military EOD or civilian UXO (retired EOD or equivalent staff).
- All persons and equipment will undergo decontamination at a location (at the perimeter of, but inside the controlled work area) designated before the start of closure work.
- A list of personnel and alternatives responsible for site safety, response operations, and protection of public health will be posted.
- Procedures for emergency medical care for injuries and toxicological problems will be addressed.
- Routine and special training required for responders will be discussed.
- A facility description including availability or resources such as roads, water supply, electricity and telephone service will be included.
- Establishment of procedures for protecting workers from weather-related problems.

The SSHP will be consistent with the Closure Plan; will be revised, as necessary, to address any additions and/or changes in planned activities; and will be provided to closure personnel before initiation of closure activities.

4.3 MOBILIZATION AND SITE PREPARATION

Mobilization and site preparation during the initiation of final closure will involve the following tasks:

- Initial inspection of the C-Demo site for surface UXO hazards to facilitate vegetation mowing.
- Mowing the surface vegetation to facilitate subsequent closure activities.
- Identification and marking of the C-Demo OB/OD site boundaries.
- Conducting a surface UXO survey and clearance.
- Establishment of controlled work zone boundaries including remediation work areas as well as decontamination and waste staging areas/locations.
- Marking of any utility hazards.
- Potentially conducting a geophysical investigation to identify former/buried OB/OD treatment pits and trenches as well as potential UXO.

Additional site preparation actions may also be warranted based on site conditions at final closure.

4.4 SAMPLING AND ANALYSIS

At the initiation of final closure, a sampling and analysis program will be conducted to provide site characterization data to evaluate the nature and extent of contamination. This will involve sampling and analysis of the following media at the C-Demo OB/OD site:

- Surface and subsurface soils;
- Surface water and sediments (including onsite swales as applicable); and
- Groundwater.

A Sampling and Analysis Plan is presented in Appendix D. A modification to the technical approach presented in Appendix D may be warranted at final closure because of advances in site characterization and analytical methods. Revision to the Sampling and Analysis Plan would be addressed, as necessary, in an amendment to this Closure Plan.

4.5 RISK-BASED CLOSURE STANDARDS

Risk-based closure standards will be established for HCOCs that are statistically significant compared with background and exceed applicable screening criteria. The risk-based closure standards will ensure the following:

- Total cumulative Hazard Index (HI) of 1.0 or less for noncarcinogens;
- Total cancer risk in the range of 1E-04 to 1E-06 for individual carcinogens;
- Total cancer risk of 1E-04 or less for all carcinogens; and
- Concentrations of HCOCs remaining at the site will not result in contamination of other environmental media of concern, including the groundwater beneath the unit.

The risk assessment protocol to be used for the implementation of these standards is provided in Appendix E based on current Virginia Department of Environmental Quality (VADEQ) guidance. A modification to this technical approach may be warranted at final closure because of potential updates to the VADEQ guidance. These revisions to the risk-assessment protocol would be addressed, as necessary, in an amendment to this Closure Plan.

4.6 SUBSURFACE UXO CLEARANCE

Subsurface UXO is expected to be minimal at the C-Demo OB/OD site. Trained EOD technicians would destroy items using prescribed disposal techniques. Potentially dud producing ordnance is detonated by addition of an explosive charge. Items were not fired or launched at C-Demo. Subsurface UXO that is within a contaminated soil layer will be cleared. Other subsurface UXO would be subject to appropriate remediation actions commensurate with applicable Department of Defense criteria (based on future land use), remediation procedures, and safety requirements at final closure. Subsurface UXO clearance generally involves detonation in place of UXO that is unsafe to move (a typical condition for subsurface UXO) or excavation followed by onsite or offsite disposal.

4.7 EXCAVATION OF CONTAMINATED SOIL

Soils that do not meet risk-based clean closure standards will be excavated, removed, and properly disposed off-site. The maximum depth of excavation will not extend past the seasonal low water table, or bedrock, whichever is encountered first. Minimal soil excavation/removal is anticipated at this time and will be performed with standard equipment such as a front end loader, a backhoe, and a truck-mounted dump trailer (or use of other suitable containers). The soil removal areas will be identified as contamination cells that exceed risk-based cleanup standards. The initial boundary of each contamination cell will be defined as midway between adjacent sampling points. However, at the discretion of MCCDC Quantico, additional samples might be obtained to refine the contamination cell "footprint." Verification sampling based on wall samples from the excavation pit will be used to demonstrate clean closure as discussed in Appendix D. Field screening methods (as appropriate) for those HCOCs that exceed risk-based cleanup standards would be used for this evaluation. As the material is excavated, it will be loaded into the roll-off containers or other suitable containers (leak-proof with sealable lids) for temporary storage as investigation-derived waste (IDW) in a staging area (see Section 4.9) before offsite disposal. This will prevent additional and unnecessary contamination of other areas.

Once clean-closure is verified, the excavation pit will be backfilled with clean soil.

4.8 DECONTAMINATION OF PERSONNEL AND EQUIPMENT

4.8.1 Temporary Decontamination Area

Before the excavation activities, a temporary decontamination area for heavy equipment will be constructed. The decontamination area will have approximate dimensions of 20 feet x 20 feet. This area will be graded with at least a 2 percent slope toward one corner of the area. A berm constructed with sand bags, or an equivalent material, will be constructed around the edges of this area. The berm will effectively contain the decontamination water. The area will be lined with an appropriate synthetic plastic liner to prevent infiltration of decontamination water into the soils. The liner must be able to sustain the stress caused by moving the heavy equipment in and out of the area for decontamination. The area will drain into a container. Alternatively, rinse water and other wastes generated during decontamination will be transferred into a clean container or tank. This proposed decontamination area has been designed so as not to meet the definition of a RCRA surface impoundment. At the conclusion of the closure work the temporary decontamination area will be dismantled, properly characterized, and disposed in accordance with Section 4.9.

4.8.2 Decontamination of Worker and Small Equipment

Workers and small equipment will be decontaminated in the personnel decontamination area. Personnel will decontaminate small equipment, pass it through to appropriately protected persons within the rinse area, remove contaminated clothing, and enter the rinse area. Workers and small equipment will then be rinsed and moved into the final rinse area. Within the final rinse area, small equipment will be rinsed, workers will don clean clothing, and then workers will exit the decontamination area. The equipment will be stored at the predesignated location and allowed to air dry, and workers will proceed to the nearest shower facility for full body decontamination. Personnel will decontaminate after each work period. Small equipment will be decontaminated after each work shift. Sampling equipment will be decontaminated before being used and after each sample is collected (see Appendix D).

4.8.3 Management of PPE

Personnel protection equipment (PPE) decontamination will be accomplished commensurate with OSHA 29 CFR 1910.120 requirements. At a minimum, it will include the following:

- PPE will be decontaminated between uses/areas, and upon completion of work;
- All decontamination will take place in the temporary decontamination area; and
- The rinse water will be handled and disposed as IDW.

4.8.4 Decontamination of Heavy Equipment

Heavy equipment will be decontaminated between uses/areas and upon completion of work. Decontamination of heavy equipment involves rinsing the area of the equipment that comes into contact with the contamination with high pressure water/steam. All decontamination will take place in the temporary decontamination area. The rinse water will be handled and disposed as IDW.

Before decontamination process, deionized water will be run through a spray nozzle to collect a prerinse sample. After the high pressure water/steam wash, a postrinse water sample will be collected by pouring deionized water over the surface area of the heavy equipment that had come into contact with the waste. The pre- and postrinse water samples will be analyzed for the HCOC. The decontamination procedure will be repeated until all HCOCs are present in the postrinse sample at levels statistically no greater than those in the prerinse sample.

4.9 WASTE MANAGEMENT

Excavated soils and other closure wastes will be immediately placed into leak-proof containers with sealable lids (e.g., roll-off containers). The containers will be large enough so that the excavation equipment will not overshoot the containers. The collection area for the excavated soils will be established immediately adjacent to the excavation zone. At the collection area, two 10-mil layers of plastic sheeting will be placed on the ground to collect any soil that spills during the filling of the containers. Containers will be placed on top of the plastic during filling. Once filled, the containers will be moved to the predesignated holding location to be sampled, characterized, and disposed. The plastic sheeting will be packed up immediately, placed in leak-proof sealable containers, and moved to the holding location. Until sample results are available, all waste materials generated during closure activities will be considered hazardous waste and appropriately labeled. Soil falling onto the plastic sheeting will be continuously picked up and put into the soil containers. Soil will not be allowed to accumulate on the plastic. All soil and plastic will be picked up and properly containerized by the end of each work shift.

Closure wastes will initially be managed as IDW commensurate with current VADEQ policy. All closure wastes will be subject to TCLP and energetic analyses and listed as waste as identified in Appendix D. Additional analyses will be conducted as required by the accepting waste treatment, storage, and disposal (TSD) facility. If drums are used to collect the waste, the number of samples to be collected will be equal to the cube root of the total number of drums in the lot. If larger containers (i.e., roll-off containers) are used to collect the wastes, one composite sample will be collected from each container. Laboratory analysis turnaround time will be as expedient as possible. If the waste is classified and labeled as hazardous it shall be properly transported and disposed within 90 days.

Closure wastes will be transported to an appropriate TSD facility commensurate with waste characterization results. Hazardous waste will be sent to an authorized Subtitle C landfill or alternative hazardous waste TSD in accordance with applicable Land Disposal Restrictions. Solid waste will be sent to a Subtitle D landfill.

The disposal of wash water may consist of discharge to a public wastewater treatment facility, which is permitted under the Clean Water Act regulations to accept the constituents found in the wash water. Prior approval will be obtained before the wash water is discharged to a publicly owned wastewater treatment facility hazardous and solid waste handlers will require testing information to satisfy land disposal restrictions and/or compliance with the receiving landfill's permit conditions. The accepting TSD facility may perform confirmatory testing on the incoming waste. If the representative sample from the waste container is found to be hazardous, then the container must be transported to a RCRA-permitted hazardous waste TSD facility by a permitted hazardous waste transporter.

UXO not treated in place (and safe to move) and munitions debris (e.g., fragmentation, casings, etc.) will be taken to a secure staging area for segregation classification and containerization by EOD/UXO specialists. Segregation will be based on the type of metal to facilitate recycling. Items determined to be hazardous because of energetic content or energetic contamination will be classified as hazardous waste and will be demilitarized pursuant to RCRA requirements as well as applicable Department of Defense and MCCDC Quantico policies and procedures.

The contractor transporting hazardous waste will be a Virginia-permitted hazardous waste transporter. The waste will be appropriately manifested and transported to an authorized (RCRA permitted or interim status) hazardous waste transfer or disposal TSD facility. MCCDC Quantico, the transporter, and the receiving facility will possess the required USEPA Identification Numbers. Before transporting hazardous waste or offering hazardous waste for transport, MCCDC Quantico will package and label the waste in accordance with 9 VAC 20-60 Part III (Regulations Applicable to Transporters of Hazardous Waste) and applicable U.S. Department of Transportation requirements (49 CF 171-179).

5.0 CLOSURE MILESTONES

5.1 CERTIFICATION OF CLOSURE

Upon completion of the appropriate final closure activities, MCCDC Quantico will submit to VADEQ a certification signed by an independent professional engineer registered in the Commonwealth of Virginia stating that the facility has been closed in accordance with the VADEQ-approved Closure Plan. This certification will be composed of a report that, at a minimum, includes the following: a summary of major field activities, an explanation of modifications and variances from the VADEQ-approved Closure Plan, complete analytical results including QA/QC data, statistical analyses results, and a certification of closure signature form. An example of a certification of closure signature form is presented in Appendix F. The certification will be submitted by registered mail to VADEQ within 60 days of completion of closure.

5.2 CLOSURE REPORT AND RECORDKEEPING

A Closure Report summarizing the closure activities will be prepared upon completion of the closure to support the closure certification. In the case of a clean-closure attempt, the report will contain all of the relevant data necessary for VADEQ to determine whether the closure standards have been met, following which closure will be acknowledged and the facility released from financial assurance regarding the closure work. Closure is contingent on VADEQ's approval of the closure certifications and the closure report.

At a minimum, the closure report will include the following:

- Summary of what occurred during closure;
- Vertical and lateral extent of excavation, both in narrative and diagram form;
- The results of all statistical analyses and sample calculations supporting the closure conclusions;
- The results of all risk assessments and sample calculations;
- A summary sheet for all sampling results;
- A copy of the laboratory generated sampling analysis form;
- A summary of QA/QC findings; and
- A copy of all waste manifests for closure-generated wastes.

Clean closure is contingent on VADEQ's approval of the closure certifications and the closure report.

If the facility is subject to a closure under the industrial/occupational scenario, a signed Notice of Use Limitation will also be included in the report.

A copy of the closure report and the results of any additional sampling and analysis will be kept on file at MCCDC Quantico.

5.3 SCHEDULE FOR CLOSURE

Final closure of the C-Demo OB/OD site will begin within 45 days after notification to VADEQ. Closure activities will be completed within 180 days of initiation of closure. Also, hazardous waste can only be accumulated for less than 90 days without a permit. MCCDC will submit a written extension request to VADEQ for consideration at least 30 days before the existing deadline of closure completion if closure will require more than 180 days to complete. A schedule for closure is shown in Table 5-1.

5.4 CLOSURE PLAN AMENDMENT

If changes in closure conditions affect this Closure Plan, the plan will be amended. Modification requests, if required, will be made at least 60 days before the change in operation or design occurs, or no later than 60 days after an unexpected event has occurred that has affected the Closure Plan. The Closure Plan may be amended by a written request from MCCDC Quantico to VADEQ for approval. The written request will include a copy of the proposed amendment and a detailed justification. The updated Closure Plan will be sent to VADEQ.

TABLE 5-1

SCHEDULE OF CLOSURE
MCCDC, QUANTICO, VIRGINIA

Activity	Day
Initiate Closure Activities/Mobilization	0[1]-30
Site Preparation	31-45
Sampling and Analyses	46-106
Establish Risk-Based Closure Standards and, as necessary, Conduct Removal Actions	107-165
Finalize Closure Report Documentation	166-180
Submit Certification of Closure	181-240

1 Date when the C-Demo Area is closed, transferring, or transferred.

6.0 CLEAN CLOSURE COST ESTIMATE

MCCDC Quantico is a Federal Facility and is exempt from the cost estimate requirements.

7.0 FINANCIAL ASSURANCE FOR CLOSURE

MCCDC Quantico is a Federal Facility and is exempt from the financial assurance requirements.

8.0 CONTINGENT CLOSURE PLAN

8.1 INTRODUCTION

The intent of MCCDC Quantico is to accomplish a risk-based clean closure of the soils at the C-Demo OB/OD site at final closure (i.e., when the C-Demo area [range] is closed, transferred, or transferring). This Contingent Closure Plan is provided in the event that the extent of contamination makes it not feasible to accomplish clean closure. The Contingent Closure Plan will be implemented and the C-Demo OB/OD site would be closed with waste in place. Although this Contingent Closure Plan is based on closure as a landfill, alternative remediation technologies will be evaluated at final closure including (but not limited to) bioremediation, phytoremediation, and natural attenuation monitoring. The flexibility for closure remediation requirements is based on "Standards Applicable to Owners and Operators of Closed and Closing Hazardous Waste Management Facilities, Post-Closure Permit Requirements and Closure Process, Final Rule" (Federal Register, October 22, 1998, Vol. 63, No. 604).

These alternative contingent closure approaches would require an amendment to the Contingent Closure Plan and/or Contingent Post-Closure Care Plan. A Groundwater Monitoring Plan to address closure of the groundwater will be submitted within 60 days of the determination that the C-Demo OB/OD site must close as a landfill. Additionally, closure activities specified in this Contingent Closure Plan will comply with applicable sections of the OSHA Hazardous Waste Operations and Emergency Response requirements 29 CFR 1910.120 commensurate with Section 4.2 of the Closure Plan.

8.2 CONTINGENT CLOSURE ACTIVITIES

If the determination is made that clean closure or closure to risk-based standards cannot be achieved and contaminated soil has been removed to a point that remains above the seasonal low water table elevation, RCRA contingent closure and post-closure will be implemented in accordance with the approved Contingent Closure Plan and Contingent Post-Closure Plans. Contingent closure of the C-Demo OB/OD site will be conducted under the surveillance of an independent professional engineer registered in the Commonwealth of Virginia. Technicians and engineers performing field tests and surveillance will report observations, measurements, and test results to the engineer. The engineer will recommend acceptance or rejection of the work, as units, or as a whole, to MCCDC Quantico.

8.3 BACKFILL

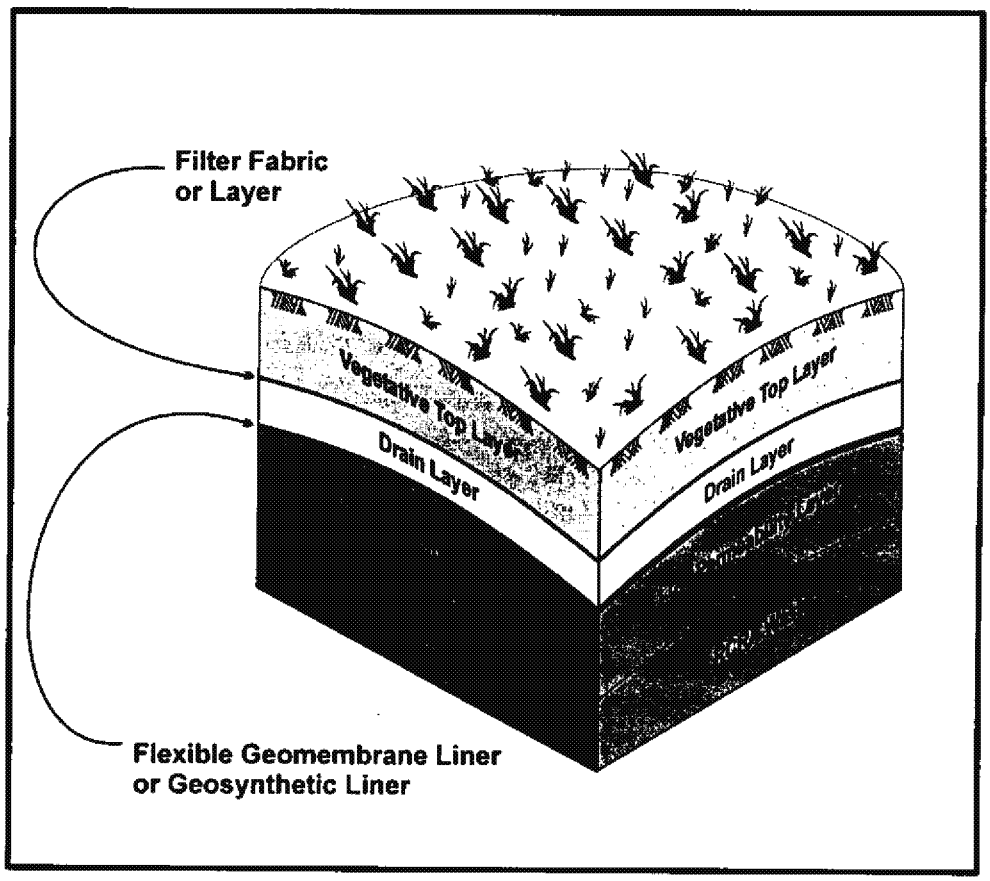
The depression caused by any excavation of the contaminated soil will be backfilled with uncontaminated (defined as not statistically significant using the Cochran's Approximation to the Fisher Student's t-Test HCOC above performance standard levels) onsite or offsite native soils. This soil will be placed in 6-inch lifts and compacted to at least 90 percent of its maximum dry density and within 2 to 4 percent of the optimum moisture content (as determined in the Standard Proctor test in ASTM D698). The soil will be compacted with a vibratory sheepsfoot compactor or equivalent equipment. The compacted soil will be free of clods, rock, fractured stone, debris, cobbles, rubbish, roots, and other deleterious material. The area will be graded sufficiently for the establishment of contours for the cover. Soil backfill testing methods are identified in Appendix G. All test results will be submitted to VADEQ with the closure completion certifications. A RCRA cap will be placed over the site and extend at least 5 feet beyond the contaminated area. A full discussion of the cover is contained in Section 8.4 of this plan.

8.4 FINAL COVER

Proposed Final Cover: The final cover will be a RCRA cap constructed in accordance with USEPA's recommended cover design found in the USEPA guidance document titled *Requirements for Hazardous Waste Landfill Design, Construction and Closure* (1989). The document specifically recommends a standard final cover of 2 feet of topsoil, a 1-foot drainage layer, and a 40-mil Flexible Membrane Liner (FML) with a 1-foot bedding layer as well as a 2-foot clay liner (Figure 8-1). The final cover will include the following elements from bottom to top:

Bottom: A compacted clay layer, consisting of two layers: (1) a bottom 2-foot clay layer lying wholly below the frost zone, with a minimum thickness of at least 2 feet and a maximum in-place saturated hydraulic conductivity of 1×10^{-7} cm/sec, and (2) a 40-ml FML under a 12-inch sand bedding layer. A full discussion of the low-permeability clay layer and the FML is contained in Section 8.4.1.

Middle: A middle layer consisting of two components: (1) a soil drainage layer with a minimum thickness of 1 foot and a minimum hydraulic conductivity of 1×10^{-2} cm/sec that will minimize water infiltration into the low-permeability layer and will have a final bottom slope of at least 3 percent after settlement and subsidence, and (2) a geosynthetic filter fabric to prevent fine particles from the final cover from clogging the drainage layer. A full discussion of the geosynthetic filter fabric and the drainage layer is contained in Section 8.4.2.



DRAWN BY: LR — DATE: OCT 00	Tetra Tech NUS, Inc.	CONTRACT NO.: 7692	OWNER NO.: 8100
CHECKED BY: MM — DATE: OCT 00	Landfill Cap Description C-Demo OB/OD Site MCCDC, Quantico, Virginia	APPROVED BY: [signature] — DATE: 10/18/0	
COST/SCHED-AREA		APPROVED BY — DATE	
Not to Scale		DRAWING NO.: Figure 8-1	R

Top: The soil cover will be at least 24 inches thick. The effects of freezing on the liner are accounted for because the regional maximum frost penetration depth for the area is 12 inches. The soils selected will be able to support vegetation that will effectively minimize erosion. The topsoil will be either a loam or loamy sand or be of the following USCS soil types: GM, GC, SM, SC, ML, or CL. The upper 6 inches of this layer will not be compacted to promote root development. The final slope will be 3 to 5 percent. A full discussion on the top layer is contained in Section 8.4.3.

All test results will be submitted to VADEQ with the closure completion certifications. A final detailed report on the construction inspection program to monitor the closure of the C-Demo OB/OD site will include at a minimum: backfilling, consolidation, compaction, sampling, and testing of the backfill; drainage layer and clay cap; in-place depth of the clay-cap, drainage layer, and soil cover; establishment of vegetation; erosion control measures; and final site survey. The final report must be submitted within 60 days (with certification) after completion of closure.

8.4.1 Low-Permeability Clay Layer

The clay materials will be capable of yielding a maximum in-place saturated hydraulic conductivity of 1×10^{-7} cm/sec. The proposed clay materials will be tested in the laboratory before installation to demonstrate the ability of the selected material to achieve the required criteria. The following tests will be conducted on the clay borrow source(s) before use:

1. Determine the plastic limit, liquid limit, and plasticity index (Atterberg Limits) of the clay materials using ASTM method D4318.

2. Determine the moisture content of the clay materials using ASTM D2216.

3. Determine the density of the clay materials using ASTM D2922, ASTM D1556, ASTM D2167, or ASTM D2937.

4. Determine the moisture-density relationship of the clay materials using ASTM D698.

5. Classify the soil type (SC, CL, CH, ML, MH) using ASTM D2487 and ASTM D2488.

6. Determine the permeability of the clay materials using Method 9100 contained in "Test Methods for the Evaluation of Solid Waste Physical/Chemical Method", (SW-846), 3rd Edition, 1986, as updated.

Testing data on the clay borrow sources(s), including a moisture/density curve based on test results for proposed borrow clay, shall be submitted to an independent Virginia-registered professional engineer for approval before construction of the clay layer in accordance with the closure schedule. MCCDC Quantico will also provide a moisture/density curve with the range of density and moisture content where permeability is acceptable. This region under the moisture/density curve would then become the acceptable specification for the material. If the result of any test indicates that the in-place hydraulic conductivity may not meet the 1×10^{-7} cm/sec standard, then the extent of the failure shall be determined by MCCDC Quantico and appropriate adjustments shall be made to correct the failure.

The low-permeability layer must be entirely below the maximum depth of frost penetration estimated for the area in which the facility is located. According to the Virginia Department of Conservation and Recreation's Division of Soil and Water Conservation, the maximum frost penetration depth for the area is approximately 8 inches. Therefore, only the soil layer will be affected and the low-permeability clay layer will be at least 48 inches below (24-inch top soil, 12-inch drainage layer, and 12-inch FML sand bedding layer) the maximum frost depth.

The layer will be placed in 6-inch lifts and compacted to 95 percent of its maximum dry density and within 2 to 4 percent of the optimum moisture content as determined in the Standard Proctor test (ASTM Method D698). The clay will be compacted with a vibratory sheepsfoot compactor or equivalent equipment. The compacted soil will be free of clods, rock, fractured stone, debris, cobbles, rubbish, roots, and other deleterious material. When weather conditions are favorable, the clay surface will be sealed with a smooth drum vibratory roller to present desiccation or erosion.

Clay liner testing methods identified in Appendix G will be used onsite during construction to ensure adequate construction methods. Because the correlation between moisture density and permeability will be established as above, test results falling within the region identified as above will be considered acceptable. Test results falling outside the region will be unacceptable and the cap will be removed and replaced. The final grade will be such that a slope of 3 percent to 5 percent will be maintained after allowance for settlement and subsidence. All test results will be submitted to VADEQ with the closure completion certifications.

A synthetic liner system shall include a 40-ml FML designed to eliminate the need for field seaming. The cap installer will be specialized in the installation of synthetic liners and caps. The following items will be documented by the installer and made available for viewing by VADEQ, including:

- Complete identification and material specifications for all components of the synthetic cap including resin type, physical properties, and other pertinent data.

- Documentation of factory seam tests.

- A detailed construction inspection program, with test procedures, that follows the criteria included in the QA/QC document to be developed if contingent closure is to be implemented.

- In addition, for the FML, the manufacturer will provide documentation of random sampling for uniformity, thickness (ASTM D374), tensile properties (ASTM D 638), and tear resistance (ASTM D 1004).

- Where possible, the above items must be made available before the actual installation of the FML and the other cap components.

- The synthetic cap layout will be located where applied stresses are minimal and will take into consideration any expansion and contraction anticipated use to ambient temperature variations. Excessive slack will be avoided to minimize rippling of the liner during placement of the drainage layer and vegetative support soil. The liner will overlay at least 2 feet of clay having a maximum saturated hydraulic conductivity of 10^{-7} cm/sec.

8.4.2 Drainage Layer

Areas adjacent to the landfill cap must be graded to drain away from the site. Because the area will be the high feature in the immediate vicinity, the only water contacting the landfill cap areas will be rain falling directly onto it. Because of the physical characteristics of the soil, any storm water from other areas will tend to percolate down through to the soil rather than drain in defined channels. Also, any swales graded in an attempt to provide run-off channels would rapidly be filled in by wind-blown sand. Therefore, efforts will be concentrated on maintaining adequate drainage off the cover whereas run-on should not be a significant factor.

The clay cap will be overlaid with at least 12-inch-thick drainage layer (above the 12-inch sand FML bedding area) having a permeability not less than 1×10^{-2} cm/sec to minimize water infiltration into the clay layer.

Granular material will be no coarser than 3/8 inch, and classified as SP or GP using ASTM D2487 and ASTM D2488. The material will be smooth and rounded, will not contain any debris, nor will it contain fines that might lessen permeability. The granular material shall be screened or washed before

construction to remove fines that may promote clogging and shall be compacted to at least 90 percent of its maximum dry density as determined in the modified Proctor Test (ASTM Method D-1557). Placement of the granular material will be observed by the independent professional engineer. The final slope on the bottom of the drainage layer will be sloped 3 percent to 5 percent after allowance for settlement and subsidence. All test results will be submitted to VADEQ with the closure completion certifications.

To prevent clogging, the drainage layer will be overlaid with a synthetic geotextile fabric filter. The synthetic filter material shall be a nonwoven, polypropylene mat with sufficient tensile strength and durability to withstand the applied force of the top soil layer for the duration of the closure and post-closure periods without breakdown or a reduction in its ability to perform as designed. The synthetic geotextile filter shall be installed and anchored in accordance with the manufacturer's specifications.

The drainage layer must slope to an exit drain that allows percolated water to be efficiently removed. The drainage layer and filter fabric layer will be designed to allow free drainage of infiltrating surface water to perforated drainage pipe. The perforated collection perimeter drains shall be embedded in larger diameter stone to prevent sand from clogging the drainage pipes. The drainage system shall be designed to accommodate a 25-year, 24-hour storm. Drainage structures, as needed, will be constructed to channel and redirect surface water away from the covered area.

Design specifications of the drainage pipe, drainage media, and filter fabric as well as design plans for the RCRA cap shall be submitted to VADEQ for review and written approval before construction as required in the closure schedule (see Section 8.7).

The following items related to the geotextile filter will be documented by the installer and made available for viewing by VADEQ, including:

- Complete identification and material specifications for all components of the synthetic cap including resin type, physical properties, and other pertinent data.

- A detailed construction inspection program, with test procedures, that follows the criteria included in the QA/QC document to be developed if contingent closure is to be implemented.

- In addition, for the geotextile fabric, the manufacturer will provide documentation of quality control certifications for mass per unit area (ASTM D-5261), thickness (ASTM D-5199), trapezoidal tear strength (ASTM D-4533), grab tensile strength (ASTM D-4632),

burst strength (ASTM D-3786), puncture strength (ASTM D-4833), apparent opening size (ASTM D-4751), and permittivity (ASTM D-4491).

Where possible, the above items must be made available before the actual installation of the geotextile and the other cap components.

It is not anticipated that a subsurface gas venting system will be required because of the nature of the contamination. The generation of subsurface gases is not expected from the soils or groundwater from this area.

8.4.3 Soil Cover

The final soil cover will consist of 2 feet with a vegetated surface component of grasses, the surface of which slopes uniformly at least 3 percent but not more than 5 percent after allowance for settlement and subsidence.

The cover crop for the vegetative layer shall be well adapted to survive conditions with minimum maintenance for the location. A cover crop will not be chosen that normally has root material long enough to penetrate the cap. The local extension office should be contacted for a recommended crop. The type of fertilizer and application rate for the fertilizer will be as recommended by the U.S. Department of Agriculture, the local extension office, or the Virginia Department of Conservation and Recreation.

8.5 GROUNDWATER MONITORING

Within 60 days of the determination that the facility must close with waste in place, a complete Groundwater Monitoring Plan will be submitted to VADEQ. This Groundwater Monitoring Plan will be a stand-alone document that will be part of the groundwater monitoring program. Once approved, these plans will be followed during the post-closure care period before issuance of the post-closure care permit. Upon approval, the groundwater monitoring for the sites would be implemented immediately in accordance with the approved Groundwater Monitoring Plan.

8.6 SECURITY

MCCDC Quantico will prevent the unknowing entry and minimize the possibility for the unauthorized entry of persons or livestock onto the landfill by installation of a 5-foot-high chain link fence around the site. Also, a sign with the legend, "**DANGER – UNAUTHORIZED PERSONNEL KEEP OUT**," shall be posted at each entrance to the site and at other locations in sufficient numbers to be seen from any approach to

the site. The legend will be in English and in any other language predominant in the area surrounding the unit and shall be legible from a distance of at least 25 feet.

8.7 CONTINGENT CLOSURE SCHEDULE

The facility shall comply with the contingent closure schedule as provided in Table 8-1.

8.8 CONTINGENT CLOSURE PLAN AMENDMENT

If the changes in closure conditions affect the Contingent Closure Plan, the plan will be amended. Modification requests, if required, will be made at least 60 days before the change in operation or design occurs, or no later than 60 days after an unexpected event has occurred that has affected the Contingent Closure Plan. The updated plan will be sent to VADEQ.

8.9 CONTINGENT CLOSURE CERTIFICATION, SURVEY PLAT, AND DEED NOTATION

Final contingent closure of the sites' locations will be supervised by an independent professional engineer registered in Virginia. Within 60 days of completion of contingent closure, certification of contingent closure in accordance with the approved plan would be sent by registered mail to the Director of VADEQ. The certification would be signed by the owner/operator and by an independent professional engineer registered in Virginia.

Within the time frame established by the contingent closure schedule (see Table 8-1), MCCDC Quantico will also submit a survey plat (prepared and certified by a professional land surveyor) of the site to the local land recording authority and VADEQ. This plat will indicate the location and dimensions of the closed area with respect to permanently surveyed benchmarks. This plat will also contain a note, prominently displayed, that states the MCCDC Quantico's obligation to restrict disturbance of the hazardous waste disposal unit.

TABLE 8-1

CONTINGENT CLOSURE AND POST-CLOSURE SCHEDULE
MCCDC, QUANTICO, VIRGINIA

Activity	Time (Days)
Determine that clean or risk-based closure not possible or feasible and notify VADEQ that closure is not feasible.	0[1]
Advertise/Award closure contract.	30
Submit Groundwater Monitoring Plan for approval.	60
Prepare and submit design drawings for contingent closure cap and drainage system designs.	
Sample soil borrow sources and analyze samples in accordance with the requirements listed in the contingent closure plan.	130
Begin construction of the cover. Backfill excavated area and conduct testing. Placement and professional engineer inspection of 2 feet of clay.	140
Begin vegetation and professional engineer inspection of the cover. Construct perimeter fence and install warning signs. Establish permanently surveyed benchmarks. Sample all potentially contaminated (or decontaminated) equipment and analyze samples.	170
Submit analytical results to VADEQ to confirm that all equipment has been decontaminated. If the decontamination area liner has been torn, then implement sampling, analysis, and remediation plan to evaluate and remediate, as appropriate, the area beneath the pad.	175
Begin post-closure care and maintenance. To continue as per the Contingent Post-Closure Plan and approved Groundwater Monitoring Plan until a post-closure permit is issued.	180
Submit professional engineer and owner and operators certification of contingent closure to VADEQ with all QA/QC documentation. Submit survey plat to local zoning authority and VADEQ that notes restrictions for future land use and required notices.	180-240
Submit post-closure care permit application and permit fee to VADEQ.	180
Post-closure care groundwater monitoring and maintenance to be performed over a 30-year period.	30 years
Submit owner and operators and professional engineer certification of completion of post-closure care.	30 years

1 Initiation of contingent closure and post-closure schedule.

In addition, within the time frame established by the contingent closure schedule, a notation will be made in the property deed. The notation must state that the land has been used to manage hazardous waste, its future use is restricted, and that the survey plat has been filed with the local land recording authority and VADEQ.

9.0 CONTINGENT POST-CLOSURE CARE PLAN

9.1 INTRODUCTION

This Post-Closure Care Plan will become effective immediately after the contingent closure of the C-Demo OB/OD site is certified by MCCDC Quantico. This plan will not be applicable if clean closure or closure to risk-based standards of soils is certified and accepted by VADEQ. This plan will remain in effect until a post-closure permit, or alternative enforceable document, is issued by VADEQ for the C-Demo OB/OD site. The post-closure permit application will be submitted within 180 days of notification that clean or risk-based closure cannot be achieved (see Section 10.0).

9.2 INSPECTION AND MAINTENANCE

The site will be inspected on a weekly basis until vegetative cover is firmly established or for 6 months, whichever is longer. After the initial period, inspections will be performed monthly for the duration of the post-closure care period. The final cover will be inspected for settling that would allow ponding of water for animal vectors that may compromise the integrity of the cap, for erosion that could expose the cap, and for any other visible damage. Vegetation will be observed to check its adequacy and to prevent growth of trees and other vegetation with root systems that could damage the integrity of the cap or drainage system. Monitoring wells will be checked to ensure that caps, casings, seals, and locks have not been damaged or altered in any way that would allow contamination of the groundwater or the sample collection or might prevent sample collection. Permanent benchmarks will be inspected to ensure they have not been damaged or rendered unusable. Fencing and signs will be inspected to ensure they have not been damaged. These items are included in a post-closure care inspection checklist (see Appendix H). Each site inspection will be documented on the inspection checklist to include all findings and any corrective actions required. The following office will be the point of contact for information regarding the site:

Point of Contact:	NREA Branch (BO46)
Address:	3250 Caitlin Avenue
	Quantico, Virginia
Telephone:	703-784-7074

Maintenance activities as required will be performed following each inspection period as follows:

- Security - Signs will be repaired or replaced as they become damaged or illegible. Ground surface will be regraded, as necessary, so that the gate remains firmly anchored. The gate will be replaced, as needed, to maintain adequate site security.

- Erosion – Washouts will be repaired whenever they are detected. If the cap integrity is in question, repair activities will be conducted as soon as possible. Restoration of vegetative cover will be performed as needed.

- Cover Settlement – Settlement will be repaired by placing additional cover materials on top of the existing cover and by replacing vegetation.

- Vegetation Cover – Maintenance of the vegetative cover will include seeding, watering, and fertilizing, as needed. Tree or bush growth will be prevented within the capped areas. Mowing will be performed as necessary to control the growth of vegetative cover and to maintain it at a reasonable height above the cover.

- Run-on and Run-off Control – Drains and ditches will be cleaned and maintained to allow free drainage so that retention of storm water does not occur. High rate run-off areas will be protected by placing coarse stone, if needed, to ensure that erosion is minimal.

- Monitoring Wells – Any damage to monitoring wells will be repaired. If necessary, a damaged well will be replaced in accordance with the Groundwater Monitoring Plan.

- Leachate Removal Systems – This system will be routinely monitored. Any damage to the system will be repaired or replaced.

- Leak Detection Systems – This system will be routinely monitored. Any damage to the system will be repaired or replaced.

- Surveying Bench Marks – Bench marks will be protected and maintained.

9.3 GROUNDWATER MONITORING

The groundwater monitoring program will be initiated immediately upon approval of the Groundwater Monitoring Plan, using monitoring wells approved by VADEQ. The groundwater monitoring program will continue under the Contingent Closure Plan and Contingent Post-Closure Care Plan until a post-closure permit or alternate enforceable document is issued, at which time groundwater monitoring activities will

be in accordance with the post-closure permit conditions. Groundwater monitoring data will be analyzed using an approved statistical method to determine whether the unit has impacted groundwater quality in the uppermost aquifer. The specific details of groundwater monitoring activities will be presented in the Groundwater Monitoring Plan, to be submitted in the event that it becomes necessary to implement the Contingent Closure Plan.

9.4 POST-CLOSURE CARE SCHEDULE

Post-closure care will begin immediately upon completion of closure activities and will continue for 30 years from the date that a post-closure care plan is instituted unless reduced or extended by the Director of VADEQ. Within 60 days of completion of the post-closure care period, certification that the post-closure care was performed in accordance with the post closure care plan must be sent by registered mail to the Director of VADEQ. The certification would be signed by the owner and operator and by an independent professional engineer registered in Virginia. The contingent post-closure schedule is presented in Table 8-1.

9.5 POST-CLOSURE CARE PLAN AMENDMENT

If changes in closure conditions affect the Post-Closure Care Plan, the plan will be amended. Modification requests, if required, will be made at least 60 days before the change in operation or design occurs, or no later than 60 days after an unexpected event has occurred that has affected the Post-Closure Care Plan. The updated plan will be sent to VADEQ.

9.6 POST-CLOSURE SECURITY

Post-closure security will be implemented to prevent the disturbance of the integrity of the final cover, liner(s), any other components of the containment system, or the function of the facility's monitoring system.

MCCDC Quantico will prevent the unknowing entry and minimize the possibility for the unauthorized entry of persons or livestock onto the landfill by installation of a 5-foot-high chain link fence around the site. Also, a sign with the legend, "DANGER – UNAUTHORIZED PERSONNEL KEEP OUT," shall be posted at each entrance to the site, and at other locations, in sufficient numbers to be seen from any approach to the site. The legend will be in English and in any other language predominant in the area surrounding the unit and shall be legible from a distance of at least 25 feet.

9.7 POST-CLOSURE CERTIFICATION

Within 60 days of completion of the post-closure care period for the C-Demo OB/OD site unit, certification will be submitted to VADEQ. The certification will specify that the post-closure care period for the hazardous waste disposal unit was performed in accordance with the specifications of the approved Post-Closure Plan. The certification will be signed by the MCCDC Quantico and by an independent professional engineer registered in Virginia.

9.8 POST-CLOSURE NOTICES

The following post-closure notices will be appropriately filed and submitted by MCCDC Quantico:

- A record of the type, location, and quantity of hazardous waste disposed within the C-Demo will be submitted to the local zoning authority (or the authority with jurisdiction over local land use) and VADEQ no later than 60 days after certification of closure.

- A notation in the property deed will be made to notify, in perpetuity, any potential purchasers of the property that (1) the land has been used to manage hazardous waste; (2) use of the land is restricted to activities that will not disturb the integrity of the final cover system or monitoring system during the post-closure care period; and (3) the survey plat and record of waste disposal (noted above) have been submitted to the local zoning authority (or the authority with jurisdiction over local land use) and to VADEQ. This notification will be placed within 60 days of certification of closure of the first waste disposal unit and within 60 days of certification of closure of the last waste disposal unit.

- A certification, signed by MCCDC Quantico, that the notice in the deed has been made, must be submitted to VADEQ.

10.0 POST-CLOSURE PERMIT APPLICATION PLAN

If risk-based clean closure cannot be achieved for the C-Demo OB/OD site then MCCDC Quantico will submit a post-closure permit application to VADEQ. This permit application will include the following:

- Groundwater, soil, and surface water characterization and monitoring data;
- Long-term, post-closure care and monitoring system specifications;
- Additional site-specific data as specified in VADEQ guidance (as available).

The post-closure permit application may incorporate the Contingent Closure Plan and Contingent Post-Closure Care Plan (i.e., Sections 8.0 and 9.0, respectively of this Closure Plan) or an amended version, as appropriate.

The post-closure permit application will be submitted within 180 days of notification that clean or risk-based closure cannot be achieved.

Based on the "Standards Applicable to Owners and Operators of Closed and Closing Hazardous Waste Management Facilities, Post-Closure Permit Requirements and Closure Process, Final Rule" (Federal Register, October 22, 1998, Vol. 63, No. 604), VADEQ may issue an alternative enforceable document (in lieu of a post-closure permit) for post-closure care requirements for the C-Demo OB/OD site.

REFERENCES

U.S. Environmental Protection Agency (USEPA), 1989. *Requirements for Hazardous Waste Landfill Design, Construction and Closure.* Office of Solid Waste and Emergency Response, Washington, DC.

U.S. Environmental Protection Agency (USEPA), August 1998. *Emission Factors for the Disposal of Energetic Materials by Open Burning and Open Detonation*, Research Triangle Park, NC.

Virginia Department of Environmental Quality (VADEQ), September 1999. Memorandum from Sanjay V. Thirunagari on Groundwater Protection Standards Use at Virginia Solid Waste Facilities, September 10.

APPENDICES

APPENDIX A

PRELIMINARY SITE INVESTIGATION
ANALYTICAL DATA (1991)

- **APPENDIX A-1: BOTTLE AND PRESERVATION REQUIREMENTS**
- **APPENDIX A-2: CHAIN-OF-CUSTODY FORMS**
- **APPENDIX A-3: TABULATED ANALYTICAL DATA**

APPENDIX A-1

BOTTLE AND PRESERVATION REQUIREMENTS

BOTTLE REQUIREMENTS
TBS GAS STATION AND CHARLIE DEMO OB/OD SITE
QUANTICO, VIRGINIA

No. of Samples	Bottle Type	Parameter	Preserv.	No. of Bottles per Sample
GROUNDWATER				
3	1-l. plastic	TAL metals (t)	HNO_3	1/sample
3	1-l. plastic	TAL metals (d)	Separate container	1/sample
3	1-l. amber glass	Explosives	--	1/sample
SURFACE WATER				
2	500 ml.plastic	Lead	HNO_3	1/sample
1	1-l. plastic	TAL metals	HNO_3	1/sample
1	1-l. amber glass	Explosives	--	1/sample
SEDIMENTS				
4	250 ml. glass jar	TAL metals	--	1/sample
4	500 ml. glass jar	Explosives	--	1/sample
3	250 ml. glass jar	Lead	--	1/sample
SOILS				
13	250 ml. glass jar	TAL metals	--	1/sample
12	250 ml. glass jar	Explosives	--	1/sample
3	250 ml. glass jar	TPH and TOC	--	1/sample
1	250 ml. glass jar	TCLP metals	--	2/sample
17	250 ml. glass jar	Lead & pH	--	1/sample

Additional bottles will be provided in case of breakage. For NEESA Level E QC, no site specific MS/MSD or MS/MD are required.

APPENDIX A-2

CHAIN OF CUSTODY FORMS

Versar Laboratories INC.

CHAIN OF CUSTODY RECORD

(2)

PROJECT NO.	PROJECT NAME
3261	Quantico · Closure Plains

SAMPLERS: (Signature) Andy Kendrick (Printed) Andy Kendrick

FIELD SAMPLE NUMBER	DATE	TIME	[illegible]	[illegible]	STATION LOCATION	NO. OF CONTAINERS	TAL Metals	Explosives	LEAD, pH	REMARKS
CDM-SDØ4	9-13-91	1252		X	SD-Ø4 Ø.Ø'-Ø.5'	2	1	1		
CDM-SDØ1	"	1315		X	SD-Ø1 Ø.Ø'-Ø.5'	2	1	1		
CDM-SDØ2	9-14-91	0930		X	SD-Ø2 Ø.Ø'-Ø.5'	2	1	1		
CDM-SDØ3	"	0945		X	SD-Ø3 Ø.Ø'-Ø.5'	2	1	1		
CDM-BGØ1	"	1025		X	BG-Ø1 Ø.Ø'-Ø.5'	1	1			
TBS (~~CDM~~)-SDØ2	"	1635		X	SD-Ø2 Ø.Ø'-Ø.5'	1			1	
TBS-SDØ3	"	1645		X	SD-Ø3 Ø.Ø'-Ø.5'	1			1	
TBS-SDØ1	"	1655		X	SD-Ø1 Ø.Ø'-Ø.5'	1			1	

INDUSTRIAL HYGIENE SAMPLE

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Alan B. Margraf (signature)	9-16-91 / 1910				
(Printed) Alan B. Margraf		(Printed)	(Printed)		(Printed)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
				Sent FedEx Bill No. 7230532761 Includes 3 coolers and CoC Forms 1 thru 5.
(Printed)		(Printed)		

Distribution: Original Plus C... Accompa... Shipm... White ... ...llow) ... to C... ...tor ... ...les f...

Versar Laboratories INC.

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME
3261	Quantico - Closure Plans

SAMPLERS: (Signature)	(Printed)
Andy Kendrick	Andy Kendrick

FIELD SAMPLE NUMBER	DATE	TIME			STATION LOCATION	NO. OF CONTAINERS	PARAMETERS: TAL Metals	Explosives	TOC/TOH	TCLP - OR TAL Metals					INDUSTRIAL HYGIENE SAMPLE	REMARKS
CDM-SB05-0.0	9/12/96	11:[illegible]			SB-05 0.0'-0.5'		1	1								
CDM-SB05-10.0	"	11:40	X		SB-05 10.0'-15.0'		1	1								
CDM-SB01-0.0	"	13:30		X	SB-01 0.0'-0.5'		1	1								
CDM-SB01-1.0	"	13:40	X		SB-01 1.0-5.0'		1	1								
CDM-SB03-0.0	"	13:55		X	SB-03 0.0'-0.5'		1	1	1							
CDM-SB03-5.0	"	14:12	X		SB-03 5.0'-10.0'		1	1								
CDM-SB02-0.0	"	14:25		X	SB-02 0.0'-0.5'		1	1								
CDM-SB02-1.0	"	14:35	X		SB-02 1.0'-5.0'		1	1								
CDM-SB04-0.0	"	1500		X	SB-04 0.0'-0.5'		1	1								
CDM-SB04-5.0	"	1510	X		SB-04 5.0'-10.0'		1	1								
CDM-HS1	"	1530		X	[illegible] 0.0'-0.5'		1	1	1	2						
CDM-HS2	"	1535		X	[illegible] 0.0'-0.5'		1	1	1	2						

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Alan B. Margraf	9-16-96 1942				
(Printed) ALAN B. MARGRAF		(Printed)	(Printed)		(Printed)
Relinquished by: (Signature)	**Date / Time**	**Received for Laboratory by:**	**Date / Time**	**Remarks**	
				Sent FedEx Bill No. (Tracking) 7735[illegible] Includes 3 Coolers and COC Forms 1 thru 5.	
(Printed)		(Printed)			

Distribution: Original Plus One Accompanies Shipment [illegible]

Versar Laboratories INC.

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME
3261	Quantico - Closure Plans

SAMPLERS: (Signature) Alan B. Margraf (Printed) FRED RAMSER, ALAN MARGRAF

FIELD SAMPLE NUMBER	DATE	TIME	[redacted]	STATION LOCATION	NO. OF CONTAINERS	PARAMETERS: TAL Metals (Total)	Explosives	Dissolved TAL metals	Lead					REMARKS
CDM-SW01	9-18-91	1308		SW-01	2	1	1							[redacted]
TBS-SW02	9-19-91	1635	X	SW-02	1				1					
TBS-SW01	"	1655	X	SW-01	1				1					
CDM-MW01-1	"	1110	X	MW-01	3	1	1	1						
CDM-MW02-1	9-15-91	1005	X	MW-02	3	1	1	1						
CDM-MW03-1	"	1440	X	MW-03	3	1	1	1						

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Alan B. Margraf	9-20-91 1900	[redacted]			
(Printed) Alan B. Margraf			(Printed)		(Printed)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	
		[redacted]		Sent FedEx B.N No. 7230532761 Includes 3 coolers and COC forms 1 thru 5.	
(Printed)					

Distribution: Original Plus One Accompanies Shipment (white and yellow); Copy to Coordinator Field Files (pink).

APPENDIX A-3

TABULATED ANALYTICAL DATA

ORGANIC ANALYSIS - EXPLOSIVES IN WATER
SITE: QUANTICO, CHARLIE DEMO SITE - 08/00
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: ROY F. WESTON

SAMPLE NUMBER: UNITS	ANALYTICAL METHOD	IDL	CRQL	SW01 UG/L	MW01-1 UG/L	MW02-1 UG/L	MW03-1 UG/L
HMX	H	10	10	1.3 U	1.3 U	1.30 U	1.30 U
RDX	H	10	10	0.63 U	0.63 U	0.63 U	0.63 U
1,3,5 - TNB	H	2	2	0.56 U	0.56 U	0.56 U	0.56 U
1,3 - DNB	H	2	2	0.61 U	0.61 U	0.61 U	0.61 U
NITROBENZENE	H	3	3	1.13 U	1.13 U	1.13 U	1.69 U
TETRYL	H	9	9	0.66 U	2.40	2.47	0.66 U
2,4,6 - TNT	H	2	2	0.78 U	0.78 U	0.78 U	0.78 U
2,6 - DNT	H	2	2	0.55 U	0.55 U	0.55 U	0.55 U
2,4 - DNT	H	2	2	0.60 U	0.60 U	0.60 U	0.60 U

H - HPLC

U - NOT DETECTED

INORGANIC ANALYSIS - TAL METALS (UG/L)
SITE: QUANTICO, CHARLIE DEMO - OB/OD
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: VERSAR LABORATORIES

SAMPLE NUMBER UNITS	ANALYTICAL METHOD	IDL	CRQL	MW013 UG/L	MW013F UG/L	MW024 UG/L	MW024F UG/L	MW034F UG/L	MW031 UG/L
ALUMINUM	P	15.0	200	12300	68.0 B	15600	116	57.2 B	869
ANTIMONY	P	17.0	500	17.0 U	17.0 U	17.0 U	17.0 U	17.0 U	17.0 U
ARSENIC	F	3.0	3	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U
BARIUM	P	1.0	200	91.8	15.1	219	23.1	188	203
BERYLLIUM	P	2.0	5	2.0	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
CADMIUM	P	5.0	5	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
CALCIUM	P	10	100	2700	1870	5230	5150	24200	23000
CHROMIUM	P	4.0	10	27.6	4.0 U	74.4	4.0 U	4.4	13.6
COBALT	P	5.0	40	12.7	5.0 U	28.4	5.0 U	5.0 U	6.5
COPPER	P	5.0	20	46.1	5.0 U	652	5.0 U	5.5	5.0 U
IRON	P	1.0	20	29600	87.0 B	55300	202	27.3 B	1290
LEAD	F	2.0	50	4.8	2.0 U	5.3	2.0 U	2.0 U	3.4
MAGNESIUM	P	1.0	5	3530	801	7660	2350	10100	9530
MANGANESE	P	2.0	10	468	17.4	1370	151	88.3	91.1
MERCURY	CV	0.2	0.2	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
NICKEL	P	8.0	30	37.9	11.8	39.8	12.6	13.4	17.8 U
POTASSIUM	P	483.0	10	2300	483 U	1940	1190	8440	7200
SELENIUM	F	3.0	3	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U
SILVER	P	2.0	10	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
SODIUM	P	10	100	2440	2580	5350	5620	26500	24700
THALLIUM	F	3.0	300	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U
VANADIUM	P	3.0	200	20.9	3.0 U	99.5	3.0 U	3.0 U	3.0 U
ZINC	P	1.0	10	111	24.0 B	78.6 B	18.8 B	22.6 B	19.1 B

ANALYTICAL METHOD
F - FURNACE
P - ICP/FLAME AA

U - NOT DETECTED. THE ASSOCIATED NUMBER INDICATES SAMPLE CONCENTRATION NECESARY TO BE DETECTED.
B - NOT DETECTED SUBSTANTIALLY ABOVE THE LEVEL REPORTED IN THE LAB OR FIELD BLANKS

INORGANIC ANALYSIS - TAL METALS (UG/L)
SITE: QUANTICO, CHARLIE DEMO - 08/00
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: VERSAR LABORATORIES

SAMPLE NUMBER	ANALYTICAL METHOD	IDL	CRQL	SW01
UNITS				UG/L
ALUMINUM	P	13.0	200	1420
ANTIMONY	P	17.0	500	17.0 U
ARSENIC	F	3.0	3	3.0 U
BARIUM	P	1.0	200	113
BERYLLIUM	P	2.0	5	2.0 U
CADMIUM	P	5.0	5	5.0 U
CALCIUM	P	10	100	5380
CHROMIUM	P	4.0	10	4.0 U
COBALT	P	5.0	40	5.7 J
COPPER	P	5.0	20	7.1 J
IRON	P	1.0	20	7610
LEAD	F	2.0	50	9.1
MAGNESIUM	P	1.0	5	3400
MANGANESE	P	2.0	10	954
MERCURY	CV	0.2	0.2	0.20 U
NICKEL	P	8.0	30	8.0 U
POTASSIUM	P	483.0	10	1540
SELENIUM	F	3.0	3	3.0 U
SILVER	P	2.0	10	2.0 U
SODIUM	P	10	100	3750
THALLIUM	F	3.0	300	3.0 U
VANADIUM	P	3.0	200	3.0 U
ZINC	P	1.0	10	35.6

ANALYTICAL METHOD
F - FURNACE
P - ICP/FLAME AA
C - COLORMETRIC
CV - COLD VAPOR

J - QUANTITATION IS APPROXIMATE DUE TO LIMITATION IDENTIFIED IN THE DATA REVIEW.
U - NOT DETECTED. THE ASSOCIATED NUMBER INDICATES SAMPLE CONCENTRATION NECESSARY TO BE DETECTED.

ANALYSIS - EXPLOSIVES IN SOIL (ug/g)
SITE: QUANTICO CHARLIE DEMO - OB/OD
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: VERSAR LABORATORIES

SAMPLE NUMBER UNITS	ANALYTICAL METHOD	IDL	CRQL	SBG0100 UG/G BACKGROUND	SB0100 UG/G	SB0110 UG/G	SB0200 UG/G	SB0210 UG/G	SB0300 UG/G	SB0350 UG/G
HMX	H	1.27	2.0	NA	1.57 U	1.60 U	1.33 U	1.25 U	1.25 U	1.81 U
HMX	H	1.27	2.0	NA	1.57 U	1.60 U	1.33 U	1.25 U	1.25 U	1.81 U
RDX	H	0.98	2.0	NA	1.21 U	1.23 U	1.03 U	0.97 U	0.96 U	1.40 U
1,3,5-TNB	H	2.09	2.0	NA	2.58 U	2.63 U	2.19 U	2.06 U	2.05 U	2.98 U
1,3-DNB	H	0.59	2.0	NA	0.73 U	0.74 U	0.62 U	0.58 U	0.58 U	0.84 U
Nitrobenzene	H	0.42	2.0	NA	0.52 U	0.53 U	0.44 U	0.41 U	0.41 U	0.60 U
TETRYL	H	5.00	5.0	NA	6.16 U	6.28 U	5.24 U	4.94 U	4.91 U	7.14 U
2,4,6-TNT	H	1.92	2.0	NA	2.37 U	2.41 U	2.01 U	1.90 U	1.89 U	2.74 U
2,6-DNT	H	0.40	2.0	NA	0.49 U	0.50 U	0.42 U	0.39 U	0.39 U	0.57 U
2,4-DNT	H	0.42	2.0	NA	0.52 U	0.53 U	0.44 U	0.41 U	0.41 U	0.60 U

ANALYTICAL METHOD
H - HPLC

U - NOT DETECTED. THE ASSOCIATED NUMBER INDICATES SAMPLE CONCENTRATION NECESSARY TO BE DETECTED.
NA - NOT ANALYZED

ANALYSIS - EXPLOSIVES IN SOIL (ug/g)
SITE: QUANTICO CHARLIE DEMO - 08/00
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: VERSAR LABORATORIES

SAMPLE NUMBER UNITS	ANALYTICAL METHOD	IDL	CRQL	SB0400 UG/G	SB0450 UG/G	SB0500 UG/G	SB0510 UG/G
HMX	H	1.27	2.0	1.27 U	1.42 U	1.26 U	1.53 U
NONE	H	1.27	2.0	1.27 U	1.42 U	1.26 U	1.53 U
RDX	H	0.98	2.0	0.98 U	1.10 U	0.97 U	1.18 U
1,3,5-TNB	H	2.09	2.0	2.08 U	2.34 U	2.08 U	2.53 U
1,3-DNB	H	0.59	2.0	0.59 U	0.66 U	0.59 U	0.71 U
Nitrobenzene	H	0.42	2.0	0.42 U	0.47 U	0.42 U	0.51 U
TETRYL	H	5.00	5.0	4.99 U	5.61 U	4.97 U	6.04 U
2,4,6-TNT	H	1.92	2.0	1.91 U	2.15 U	1.91 U	2.32 U
2,6-DNT	H	0.40	2.0	0.40 U	0.45 U	0.40 U	0.48 U
2,4-DNT	H	0.42	2.0	0.42 U	0.47 U	0.42 U	0.51 U

ANALYTICAL METHOD
H - HPLC

ANALYSIS - EXPLOSIVES IN SOIL (UG/G)
SITE: QUANTICO, CHARLIE DEMO - OB/OD
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: VERSAR LABORATORIES

SAMPLE NUMBER UNITS	ANALYTICAL METHOD	IDL	CRQL	MS1 UG/G	MS2 UG/G
HMX	H	1.27	2.0	1.26 U	1.34 U
RDX	H	0.98	2.0	0.97 U	1.04 U
1,3,5-TNB	H	2.09	2.0	2.07 U	2.21 U
1,3-DNB	H	0.59	2.0	0.59 U	0.62 U
Nitrobenzene	H	0.42	2.0	0.42 U	0.44 U
TETRYL	H	5.00	5.0	4.96 U	5.29 U
2,4,6-TNT	H	1.92	2.0	1.90 U	2.03 U
2,6-DNT	H	0.40	2.0	0.40 U	0.42 U
2,4-DNT	H	0.42	2.0	2.42	0.44 U

ANALYTICAL METHOD

H - HPLC

U - NOT DETECTED. THE ASSOCIATED NUMBER INDICATES SAMPLE CONCENTRATION NECESSARY TO BE DETECTED.

ANALYSIS - TAL METALS, TOC, TRPH (MG/KG)
SITE: QUANTICO CHARLIE DEMO - OB/OD
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: VERSAR LABORATORIES

SAMPLE NUMBER UNITS	ANALYTICAL METHOD	IDL	CRQL	SB0100 MG/KG	SB0110 MG/KG	SB0200 MG/KG	SB0210 MG/KG	SB0300 MG/KG	SB0350 MG/KG	SB0400 MG/KG
ALUMINUM	P	0.4	200	24200	20900	8760	9780	7430	27600	14400
ANTIMONY	P	1.7	60	2.1 U	2.0 U	1.5 U	1.8 U	1.4 U	2.4 U	1.7 U
ARSENIC	F	0.3	10	4.5	1.9	2.0	1.9	1.6	2.4	2.8
BARIUM	P	0.1	200	221	263	37.4	32.3	61.6	29.2	60.6
BERYLLIUM	P	0.2	5	0.37	0.42	0.18 U	0.21 U	0.16 U	2.6	0.20 U
CADMIUM	P	0.5	5	0.61	0.59 U	0.44 U	0.52 U	0.41 U	0.71 U	0.51 U
CALCIUM	P	0.1	5000	152	166	193	201	234	14.1 B	400
CHROMIUM	P	0.4	10	40.1	26.7	39.9	35.1	12.9	57.3	22.3
COBALT	P	0.5	50	2.8	1.8	3.1	3.1	2.9	1.9	3.2
COPPER	P	0.6	25	41.2	23.0	5.1	6.3	8.1	49.1	21.8
IRON	P	0.2	100	42500	24000	11400	14500	10000	27500	22000
LEAD	F	0.2	3	40.7	40.1	8.5	5.8	17.2	11.5	16.9
MAGNESIUM	P	0.1	5000	724	687	485	443	371	516	522
MANGANESE	P	0.2	15	45.6	24.5	103	74.1	133	21.6	54.0
MERCURY	CV	0.1	0.2	0.12 U	0.13 U	0.10 U	0.11 U	0.10 U	0.14 U	0.09 U
NICKEL	P	0.8	40	4.9	3.1	4.7	3.9	3.4	2.0	3.7
POTASSIUM	P	48.3	5000	614	530	320	345	228	133	433
SELENIUM	F	0.3	5	0.59	0.36 U	0.24	0.29 U	0.30 U	0.48	0.29 U
SILVER	P	0.2	10	0.25 U	0.24 U	0.18 U	0.21 U	0.16 U	0.28 U	0.20 U
SODIUM	P	0.3	5000	25.5	35.0	0.27	20.1	12.7	24.1	42.0
THALLIUM	F	0.3	10	0.34 U	0.36 U	0.24 U	0.29 U	0.30 U	0.44 U	0.29 U
VANADIUM	P	0.3	50	80.8	64.4	17.7	24.1	21.9	57.6	41.3
ZINC	P	0.2	20	31.2	14.9	15.1	11.5	16.8	10.1	26.4
TOC	C	100	100	NA	NA	NA	NA	23400	NA	NA
TRPH	I	10	10	NA	NA	NA	NA	39.4	NA	NA
	% Solids			76.7	74.0	94.6	93.5	93.5	67.9	97.8

ANALYTICAL METHOD
F - FURNACE
CV - COLD VAPOR
P - ICP/FLAME AA
C - TOC ANALYZER
I - INFRARED

J - QUANTITATION IS APPROXIMATE DUE TO LIMITATIONS IDENTIFIED IN THE DATA REVIEW
K - QUANTITATION IS BIASED HIGH DUE TO LMITATIONS IDENTIFIED IN THE DATA REVIEW
U - NOT DETECTED. THE ASSOCIATED NUMBER INDICATES SAMPLE CONCENTRATION NECESSARY TO BE DETECTED
B - NOT DETECTED SUBSTANTIALLY ABOVE THE LEVEL REPORTED IN THE LAB OR FIELD BLANKS
NA - NOT ANALYZED

ANALYSIS - TAL METALS, TOC, TRPH (MG/KG)
SITE: QUANTICO CHARLIE DEMO - OB/OD
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: VERSAR LABORATORIES

SAMPLE NUMBER UNITS	ANALYTICAL METHOD	IDL	CRQL	SB0450 MG/KG	SB0500 MG/KG	SB0510 MG/KG	SBG0100 MG/KG BACKGROUND
ALUMINUM	P	0.4	200	15300	10600	17900	14900
ANTIMONY	P	1.7	60	1.9 U	1.7 U	2.3 U	2.1 U
ARSENIC	F	0.3	10	2.4	2.4	2.8	1.9 U
BARIUM	P	0.1	200	60.0	57.5	150	128
BERYLLIUM	P	0.2	5	0.69	0.20 U	4.5	0.24 U
CADMIUM	P	0.5	5	0.55 U	0.51 U	0.67 U	0.61 U
CALCIUM	P	0.1	5000	82.7	365	374	1050
CHROMIUM	P	0.4	10	25.2	18.9	9.2	17.1
COBALT	P	0.5	50	2.1	2.7	2.9	9.9
COPPER	P	0.6	25	20.5	53.7	66.3	15.0
IRON	P	0.2	100	25700	25000	33900	16000
LEAD	F	0.2	3	10.1	98.0 K	8.2	19.5
MAGNESIUM	P	0.1	5000	458	431	961	1060
MANGANESE	P	0.2	15	36.7	81.6	25.4	754
MERCURY	CV	0.1	0.2	0.11 U	0.11 J	0.14 U	0.12U
NICKEL	P	0.8	40	3.5	5.2	2.5	8.6
POTASSIUM	P	48.3	5000	362	317	64.5 U	717
SELENIUM	F	0.3	5	0.38	0.29 U	0.39 U	0.38
SILVER	P	0.2	10	0.22 U	0.20 U	4.1	0.24 U
SODIUM	P	0.3	5000	20.9	24.4	39.4	58.9
THALLIUM	F	0.3	10	0.28 U	0.29 U	0.39 U	0.34 U
VANADIUM	P	0.3	50	47.2	36.8	43.8	31.5
ZINC	P	0.2	20	11.6	69.4	12.5	40.0
TOC	C	100	100	NA	NA	NA	NA
TRPH	I	10	10	NA	NA	NA	NA
	% Solids			82.9	94.6	73.4	79.2

ANALYTICAL METHOD
F - FURNACE
CV - COLD VAPOR
P - ICP/FLAME AA
C - TOC ANALYZER
I - INFRARED

ANALYSIS - TAL METALS (UG/L), TOC, TRPH (MG/KG)
SITE: QUANTICO, CHARLIE DEMO - OB/OD
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: VERSAR LABORATORIES

SAMPLE NUMBER UNITS	ANALYTICAL METHOD	IDL	CRQL	MS1T UG/L TCLP	MS2T UG/L TCLP
ALUMINUM	P	13.0	200	900	1500
ANTIMONY	P	17.0	500	170 U	170 U
ARSENIC	F	3.0	3	30.0 U	30 U
BARIUM	P	1.0	200	574	358 B
BERYLLIUM	P	2.0	5	20.0 U	20.0 U
CADMIUM	P	5.0	5	230	50.0 U
CALCIUM	P	10	100	4380	4670
CHROMIUM	P	4.0	10	40.0 U	40.0 U
COBALT	P	5.0	40	50.0 U	50.0 U
COPPER	P	5.0	20	2740	134
IRON	P	1.0	20	60.0 U	60.0 U
LEAD	F	2.0	50	14300	390
MAGNESIUM	P	1.0	5	3160	2090
MANGANESE	P	2.0	10	362	399
MERCURY	CV	0.2	0.2	10.0 U	10.0 U
NICKEL	P	8.0	30	97.7	89.0
POTASSIUM	P	483.0	10	4380 U	4830 U
SELENIUM	F	3.0	3	30.0 U	30.0 U
SILVER	P	2.0	10	20.0 U	20.0 U
SODIUM	P	10	100	1460000	1480000
THALLIUM	F	3.0	300	30.0 U	30.0 U
VANADIUM	P	3.0	200	30.0 U	30.0 U
ZINC	P	1.0	10	13300	899
				MG/KG	MG/KG
TOC	C	100	100	3390	5,620
TRPH	I	10	10	45.7	43.2

ANALYTICAL METHOD
F - FURNACE
CV - COLD VAPOR
P - ICP/FLAME AA
C - TOC ANALYZER
I - INFRARED

U - NOT DETECTED. THE ASSOCIATED NUMBER INDICATES SAMPLE CONCENTRATION NECESSARY TO BE DETECTED.
B - NOT DETECTED SUBSTANTIALLY ABOVE THE LEVEL REPORTED IN THE LAB OR FIELD BLANKS

ANALYSIS - EXPLOSIVES IN SEDIMENT (UG/G)
SITE: QUANTICO CHARLIE DEMO - OB/OD
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: VERSAR LABORATORIES

SAMPLE NUMBER UNITS	ANALYTICAL METHOD	IDL	CRQL	SD01 UG/G	SD02 UG/G	SD03 UG/G	SD04 UG/G
HMX	H	1.27	2.0	2.37 U	2.56 U	1.58 U	1.55 U
HMX	H	1.27	2.0	2.37 U	2.56 U	1.58 U	1.55 U
RDX	H	0.98	2.0	1.83 U	1.97 U	1.22 U	1.20 U
1,3,5-TNB	H	2.09	2.0	3.91 U	4.21 U	2.60 U	2.56 U
1,3-DNB	H	0.59	2.0	1.10 U	1.19 U	0.73 U	0.72 U
Nitrobenzene	H	0.42	2.0	0.78 U	0.85 U	0.52 U	0.43 U
TETRYL	H	5.00	5.0	9.34 U	10.1 U	6.23 U	6.11 U
2,4,6-TNT	H	1.92	2.0	3.59 U	3.86 U	2.39 U	2.35 U
2,6-DNT	H	0.40	2.0	0.75 U	0.80 U	0.50 U	0.49 U
2,4-DNT	H	0.42	2.0	0.75 U	0.85 U	0.52 U	0.51 U

ANALYTICAL METHOD
H - HPLC

U - NOT DETECTED. THE ASSOCIATED NUMBER INDICATES SAMPLE CONCENTRATION NECESSARY TO BE DETECTED.

INORGANIC ANALYSIS - TAL METALS (MG/KG)
SITE: QUANTICO CHARLIE DEMO - 08/08
CASE: 5519 SDG: MUSQUANT - 1
LABORATORY: VERSAR LABORATORIES

SAMPLE NUMBER UNITS	ANALYTICAL METHOD	IDL	CRQL	SD01 MG/KG	SD02 MG/KG	SD03 MG/KG	SD04 MG/KG
ALUMINUM	P	0.4	200	22500	22600	11700	22000
ANTIMONY	P	1.7	60	3.5 U	3.2 U	1.7 U	2.1 U
ARSENIC	F	0.3	10	2.8	3.3	2.0	2.8
BARIUM	P	0.1	200	183	64.1	47.6	190
BERYLLIUM	P	0.2	5	0.41 U	2.0	0.25	1.4
CADMIUM	P	0.5	5	1.0 U	0.95 U	0.50 U	0.63 U
CALCIUM	P	0.1	5000	1250	884	54.5	2530
CHROMIUM	P	0.4	10	36.5	101	19.1	48.1
COBALT	P	0.5	50	15.1	12.5	5.3	15.4
COPPER	P	0.6	25	70.5	60.8	12.3	80.9
IRON	P	0.2	100	29800	94800	22600	56500
LEAD	F	0.2	3	60.9	14.3	19.8	14.6
MAGNESIUM	P	0.1	5000	2610	2870	335	3220
MANGANESE	P	0.2	15	747	419	142	704
MERCURY	CV	0.1	0.2	0.25 U	0.21 U	0.11 U	0.18 U
NICKEL	P	0.8	40	17.5	19.8	5.5	12.7
POTASSIUM	P	48.3	5000	802	1300	557	691
SELENIUM	F	0.3	5	0.72 U	0.46 U	0.39	0.57
SILVER	P	0.2	10	0.41 U	0.38 U	0.20 U	0.25 U
SODIUM	P	0.3	5000	116	63.4	28.0	57.0
THALLIUM	F	0.3	10	0.72 U	0.46 U	0.33 U	0.46 U
VANADIUM	P	0.3	50	45.7	126	31.6	81.7
ZINC	P	0.2	20	136	89.3	19.2	74.0
	% Solids			38.7	48.6	88.8	56.8

ANALYTICAL METHOD
F - FURNACE
CV - COLD VAPOR
P - ICP/FLAME AA

U - NOT DETECTED. THE ASSOCIATED NUMBER INDICATES SAMPLE CONCENTRATION NECESSARY TO BE DETECTED.

APPENDIX B

PRELIMINARY SITE INVESTIGATION BORING LOGS/ WELL CONSTRUCTION DIAGRAMS

- APPENDIX B-1: BORING LOGS
- APPENDIX B-2: WELL CONSTRUCTION DIAGRAMS

APPENDIX B-1

BORING LOGS

BORING LOG

PROJECT Quantico
PROJECT NO.: 3261
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 9-12-91
FIELD GEOLOGIST A. Kendrick

BORING NO COM-SB01
DRILLER: Terry Misc - H H I

	SAMPLE NO & TYPE OR ICO	DEPTH (ft) OR RUN NO	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1330	S-1 0.0-1.0	1.0			1.0	loose	tan	Silt, fine Sand, and Gravel	ML	dry, dusty, metal fragments, FILL
		2.0				Stiff to V Stiff	red Brn.	Clay & Silt, little v.f. sand, little to some gravel.	ML CL	damp, mottled, FILL
		3.0								
1340	S-2	4.0	5 8							
	1.0-5.0	5.0	7 19		5.0					
					E.O.B.			End of Boring at 5.0'		

REMARKS Analytical Samples taken: 1) 0.0' - 0.5' - Surface Grab (S-1)
2) 1.0 - 5.0' - Composite (S-2)

BORING COM-SB

PAGE 1 of 1

PROJECT: Quantico
PROJECT NO.: 3261
ELEVATION:
WATER LEVEL DATA:
(Date, Time & Conditions)

DATE: 9-12-91
FIELD GEOLOGIST: A. Kendrick

BORING NO: CDM-SB02
DRILLER: Terry Misc - H n I.

	SAMPLE NO. & TYPE OR RUN	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS CODE	REMARKS
1425	S-1 0.0-0.5	1.0			1.0	loose	tan	Silt and Fine Sand, some gr.	ML	dry, dusty, metal frags, FILL
		2.0				Stiff to V stiff	red brn.	Silt and Clay, lithic Fine	ML CL	damp, mottled w.
		3.0						sand.		orange & brown. FILL
1435	S-2	4.0	27 13							
	10-50	5.0	8 17		5.0					
					EOB			End of Boring @ 5.0'		

REMARKS: Analytical Samples taken: 1) 0.0 - 0.5' - Surf. Grab (S-1)
2) 1.0 - 5.0 - Composit (S-2

BORING CDM-S

PAGE 1

BORING LOG — NUS CORPORATION

PROJECT: Quantico — BORING NO: CDM-SB03
PROJECT NO.: 3261 — DATE: 9-12-91 — DRILLER: Terry Misc - H.M.I.
ELEVATION: — FIELD GEOLOGIST: A. Kendrick
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
S-1									
13:55 0.0-0.5	1.0			1.0	loose	tan	Silt & Fine Sand, some gravel	ML	clay, dusty, metal frags. FILL
	2.0				Stiff to v. stiff	Red Brn.	Silt & Clay, little fine sand	ML CL	damp, mottled. FILL
	3.0								
	4.0								
	5.0			5.0					
14:00	6.0	8 9	HNu 0.5		Stiff to v. stiff	Red. Brn.	Silt & Clay, trace fine	ML CL	damp, mottled w/
	7.0	9 11	1.0/2.0			Yellow.	Sand.		yellow, brn, red, tan.
S-2	8.0								Not Ground ?
14:12 5.0-10.0	9.0	8 13							
	10.0	16 17	1.0/2.0	10.0					
				EOB			End of Boring @ 10.0		

REMARKS: Analytical Samples taken: 0.0-0.5' - Surf. Grab (S-1)
5.0-10.0 - Composite (S-2)

BORING CDM-SB30

PAGE 1 of ___

BORING LOG — **NUS CORPORATION**

PROJECT: Quantico — BORING NO: CDM-SB04
PROJECT NO.: — DATE: 9-12-91 — DRILLER: Terry Misc - H.H.I.
ELEVATION: — FIELD GEOLOGIST: A. Kendrick
WATER LEVEL DATA: —
(Date, Time & Conditions)

	SAMPLE NO & TYPE OR ROD	DEPTH (ft) OF RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS CONVERSION	REMARKS
1500	S-1 0.0-0.5	1.0			1.0	loose	tan.	Silt & V.F to F. Sand, some gr.	ML	dry, dusty, no tail Crops, FILL
		2.0			2.0	Stiff	Red Brn.	Silt, sand, & clay.	ML CL	damp. FILL
		3.0				Stiff to v stiff	Red Brn.	Silt & clay, little F. sand	ML CL	damp, mottled, FILL
		4.0								
		5.0			5.0					
1505		6.0	6 / 26			v. Stiff	Red Brn.	Silt & clay, trace.	ML CL	damp, mottled w/ pink laminations
		7.0	37 / 90/.4	2.0/2.0			Yell.	v.F. Sand.		Not Ground - ?
1510	S-2 Comp	8.0								
		9.0	8 / 12							
		10.0	19 / 29	1.5/2.0	10.0					
					EOB			End of Boring at 10.0		

REMARKS: Analytical Samples: 1) 0.0 - 0.5 - Surf. Grab. (S-1)
2) 5.0 - 10.0 - Composite (S-2)

BORING CDM-S

PAGE 1

BORING LOG — NUS CORPORATION

PROJECT: Quantico — BORING NO: COM-SB05
PROJECT NO.: 3261 — DATE: 9-12-91 — DRILLER: Terry Misc - H.H.I
ELEVATION: — FIELD GEOLOGIST: A. Kendrick
WATER LEVEL DATA (Date, Time & Conditions)

SAMPLE NO & TYPE OR RUN NO.	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
S-1 0.0-0.5	1.0			1.0	100% Sc	tan	Silt and Sand, some gravel	ML	dry, dusty, metal frag Fill
	2.0				Stiff/ V. Stiff	Gravel Brn Mot	Silt and Clay, little v.	ML/CL	
	3.0						f. sand,		
	4.0								
	5.0				Stiff/ V Stiff	red/Brn	Same as Above.		damp.
S-2 5.0-7.0	6.0	4 6				6-9'			
	7.0	7 7	10/2.0						
	8.0			8.0					
	9.0				St. Stiff/ V. Stiff	orng brn.	Silt & Clay, trace v.f.	ML/CL	damp, moHed.
	10.0					@ 8'	Sand.		w/orng, brn, red, wh.
S-3(4) 10.0-15.0	11.0	6 12							New Ground @ 9'
	12.0	15 14	04/2.0						
2 Sets of S.S.	13.0								
(S-4)	14.0	4 12							
	15.0	20 32	20/2.0	15.0					
	16.0				Hard.	Orng Brn.	Silt & Clay w/ broken	ML/CL	Saprolitic
	17.0						decomp. rock frags.		V. Decomp. Schist
	18.0								damp, No H2O.
	19.0								
	20.0								
	21.0	30 45			Hard.	green/ grey	Top of Rock ≅ 21.0'	—	Chlorite Schist
	22.0	50/5		21.5 E.O.B.					decomposed.
							End of Boring @ 21.5'		

REMARKS: Analytical Samples taken 0.0-0.5 - Surf Grab (S-1) @ 11:00
10.0-15.0 - Composite (S-3) @ 11:40

BORING COM-SB05

PAGE 1 of 1

BORING LOG NUS CORPORATION

PROJECT: Quantico [illegible] Clean
PROJECT NO.: 3261
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 9-12-91
FIELD GEOLOGIST: Fred W. Ramser

BORING NO: MW-02
DRILLER: Terry [illegible]

Sample No. & Type or RQD	Depth (ft.) or Run No.	Blows 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth ft.) or Screened Interval	Soil Density Consistency or Rock Hardness	Color	Material Classification	U.S.C.S.	Remarks
						Light Brn	[illegible] some gravel	CL	0.5 [illegible] gravels [illegible]
	2					Gray Brn	Sandy silt some clay TR gravel		[illegible]
						Mottled	↓		↓
	4					↓	↓		↓
S-1	6	6 / 9 / 7 / 8	1.0 / 2.0		Very stiff	Mottled Red Yellow Tan Brown	Clay some silt tr fine gravel	CL	S-1 Dry 0.0
	8					↓	↓		↓
	10					↓	↓		↓
S-2	12	3 / 5 / 4 / 7	2.0 / 2.0		Stiff	Mottled Gray Lt Yellow Green	Clay and silt trace fine/medium [illegible]	CL	S-2 [illegible] 0.0 Blk veins [illegible]
	14					↓	↓		↓
S-3	16	5 / 5 / 7 / 6	1.3 / 2.0		Stiff	Green Mottled Red Or Brn	Clay with some silt TR/gravels	CL	S-3 [illegible] gravel [illegible]; Hit water @ 16 wet
	18						↓		Blk veins rare
							↓		0.0ppm @ GL, 9-12-91
	20								No water [illegible]
S-4	22	2 / [illegible] / 7 / 7	1.3 / 2.0		Stiff	Green Brn Red Mottled	Silty sand some clay TR fine gravels	CL	S-4 Saturated [illegible]; Measured [illegible] 1608; Measured water [illegible] 9-13-91; Green [illegible]
	24								
				TD			Bottom of hole @ 24'		

REMARKS: BGI Rig mobile on a Ford F700 [illegible] 140 lb hammer drop 30"
3¼ ID HSA, 2" split spoon samples for lithologic [illegible]
[illegible] @ [illegible] 4" [illegible] 10' screen interval [illegible]
* Augers were [illegible] for [illegible] holes, [illegible]
[illegible] was [illegible], augers
[illegible] some [illegible] soil [illegible]

BORING MW-02
PAGE 1 of 1

BORING LOG — NUS CORPORATION

PROJECT: Quant[illegible]
PROJECT NO.: 3232 [illegible]
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: [illegible]-12-91
FIELD GEOLOGIST: FRED [illegible]

BORING NO: MW-03
DRILLER: TERR[illegible]

SAMPLE NO & TYPE OR RQD	DEPTH (FT) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
S-5 15:30	26	17 / 35 / 47 / 50/[illegible]	1.5 / 2.0		[illegible]	GREEN LIGHT [illegible] + YELLOW [illegible] MOTTLED	SILT SOME CLAY AND FINE SAND W/ MED SAND AND GRAVEL	CL	S-5 [illegible] SUBANGULAR
	28								
							≈28' GREEN CRYSTALLINE GRAVELS AT CUTTINGS, ANGULAR TO SUBANGULAR [illegible]		
	30								
S-6 15:50		34 / 50/5"			[illegible]	GREEN W/ BROWN [illegible] (DK-GRY)	SILT SOME [illegible] FINE SAND W/ [illegible] GRAVEL	CL	S-6 [illegible]
	32		1.0 / 2.0						
									AUGER REFUSAL @ ≈32' NO WATER
	34								F.D.L. SUGGESTED TO [illegible] THE NIGHT TO SEE IS [illegible] WILL DEVELOP
	36								
	40						BOTTOM OF HOLE @ 32'		
							[illegible] HRS		
	42								
							MEASURED WATER LEVEL @ 25' @ 0810 HRS [illegible]-13-91		

REMARKS: GREEN MATERIAL IS GENERALLY KNOWN AS "SAPROLITE"

BORING MW-03

PAGE 2 of 2

PROJECT: QUANTICO
PROJECT NO.: 3281
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 7-12-91
FIELD GEOLOGIST: FRED [illegible]

BORING NO: MW-03
DRILLER: TERRY [illegible]

SAMPLE NO & TYPE OR RQD	DEPTH (Ft.) OR RUN NO.	BLOWS/6" OR RQD (%)	SAMPLE RECOVERY/SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/Ft.) OR SCREENED INTERVAL	SOIL DENSITY/CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	U S C S	REMARKS
						LIGHT BRN	SANDY SILT SOME GRAVEL TR/CLAY		
	2								
	4								
S-1 [illegible]	6	[illegible] / 15 / [illegible] / [illegible]	1.0/2.0		STIFF	MOTTLED WHT / YELLOW BROWN	CLAYEY SILT W/SOME FINE MED SAND	CL	S-1 DRY [illegible]
	8						(INCREASING SILT + FINE SAND CONTENT W/DEPTH)		
	10								
S-2 1500	12	7 / 16 / [illegible] / [illegible]	1.5/2.0		STIFF	MOTTLED YELLOW / [illegible]	CLAYEY SILT W/SOME [illegible] TR/COARSE SAND; SEAMS OF DK BROWN CLAY (RARE)	CL	S-2 DRY [illegible]; 2" LAYER [illegible]
	14								
S-3 1510	16	23 / 36 / [illegible] / [illegible]	1.5/2.0		[illegible]	MOTTLED WHT / YEL. TAN	SILT SOME CLAY AND FINE TO MED SAND	SC	S-3 [illegible] MOIST
	18								
	20								
S-4 1520	22	19 / [illegible] / [illegible] / [illegible]	1.6/2.0		STIFF	LIGHT GREEN [illegible] / WHT [illegible]	[illegible] SILT AND FINE SAND W/[illegible] TR/MED TO COARSE SAND	SC	S-4 [illegible]
	24								

REMARKS: B61 MOBILE RIG MOUNTED ON FORD F700, 140 LB HAMMER DROPPED 30" 3 3/8 ID HSA 2" SPLIT SPOON SAMPLES FOR LITHOLOGY ONLY

BORING MW-0[illegible]
PAGE 1 OF 2

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APPENDIX B-2

WELL CONSTRUCTION DIAGRAMS

NUS CORPORATION
A Halliburton Company

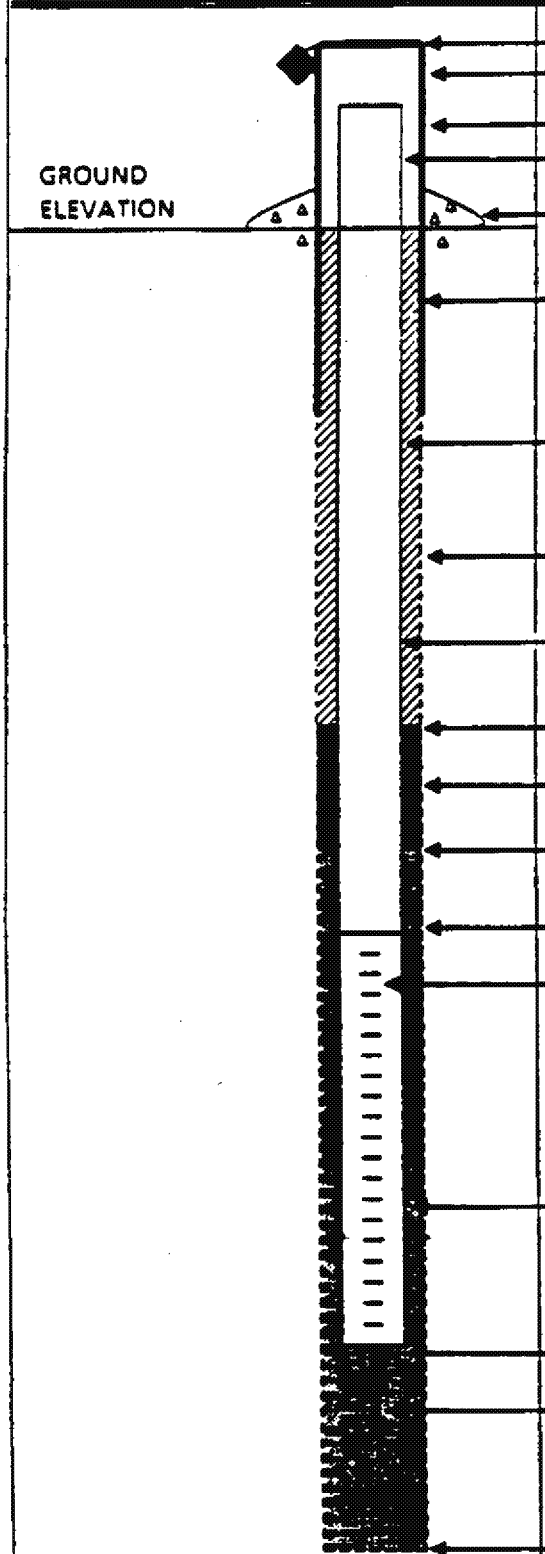
BORING NO MW-21

OVERBURDEN
MONITORING WELL SHEET

PROJECT Quantico
PROJECT NO. 2261
ELEVATION
FIELD GEOLOGIST Fred W Ramsey

LOCATION OB/OD
BORING MW 21
DATE 9-13-91

DRILLER Terry J SS
DRILLING METHOD HSA 7¾" ID
DEVELOPMENT METHOD



ELEVATION OF TOP OF SURFACE CASING:
ELEVATION OF TOP OF RISER PIPE: '

STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE : 4'0 S.S.

TYPE OF SURFACE SEAL: CEMENT PAD

I.D. OF SURFACE CASING: 6¼
TYPE OF SURFACE CASING: 7' STEEL 10 3/4

RISER PIPE I.D. 4" ID
TYPE OF RISER PIPE: SS

BOREHOLE DIAMETER: ~8"

PORTLAND TYPE I/II
TYPE OF BACKFILL: CEMENT - BENTONITE SLURRY
4 x 94lb BAGS ~ 40 GALS H2O ~ 5lbs BENTONITE

ELEVATION / DEPTH TOP OF SEAL: 17'

TYPE OF SEAL: BENTONITE PELLETS 3/8" ø
BAROID BRAND

DEPTH TOP OF SAND PACK: 19'

ELEVATION / DEPTH TOP OF SCREEN: 11'

TYPE OF SCREEN: S.S. SLOT

SLOT SIZE x LENGTH: .010" x 10'

I.D. OF SCREEN: 4" ID

TYPE OF SAND PACK: #0 GRAVEL

ELEVATION / DEPTH BOTTOM OF SCREEN: 21'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 22'
TYPE OF BACKFILL BELOW OBSERVATION WELL:

ELEVATION / DEPTH OF HOLE: 24'

NUS CORPORATION
A Halliburton Company

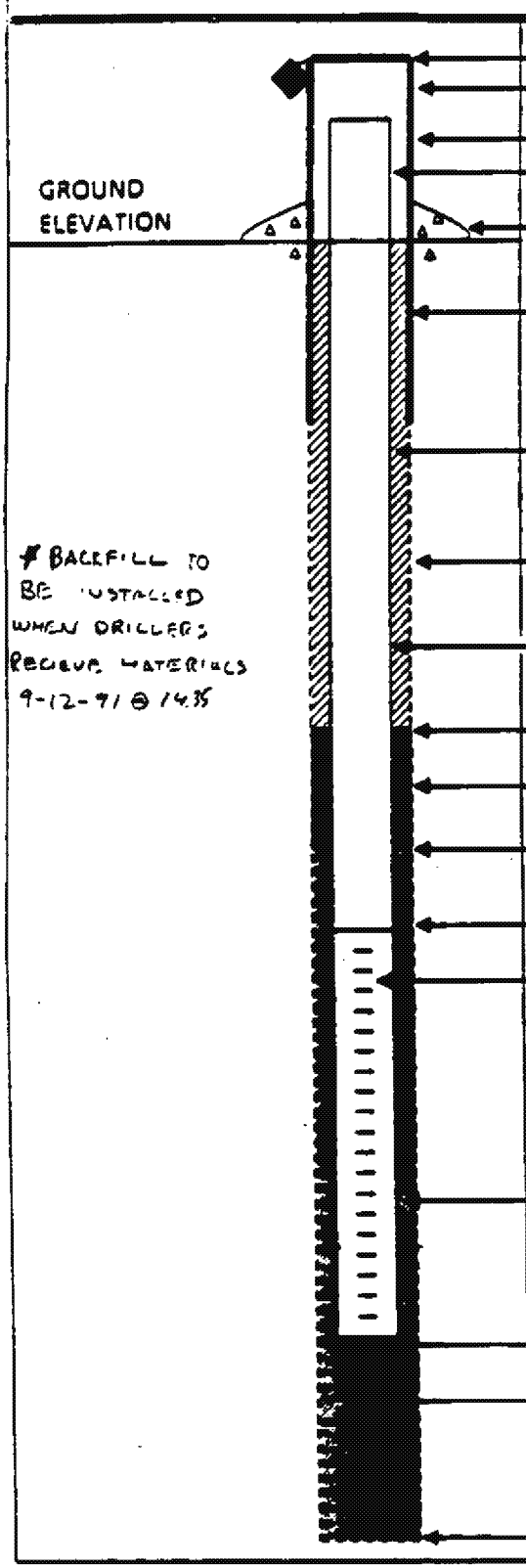
BORING NO. MW-32

OVERBURDEN
MONITORING WELL SHEET

PROJECT Quantico
PROJECT NO. 3261
ELEVATION
FIELD GEOLOGIST Fred W Ramsaur

LOCATION DOD
BORING MW-32
DATE 9-12-91

DRILLER Terry Hise
DRILLING METHOD HSA 3¼ ID
DEVELOPMENT METHOD



ELEVATION OF TOP OF SURFACE CASING :
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE :
TYPE OF SURFACE SEAL:
I.D. OF SURFACE CASING:
TYPE OF SURFACE CASING:
RISER PIPE I.D.
TYPE OF RISER PIPE:
BOREHOLE DIAMETER:
TYPE OF BACKFILL:
ELEVATION / DEPTH TOP OF SEAL: /9.5
TYPE OF SEAL: Bentonite Pellets
DEPTH TOP OF SAND PACK: /12'
ELEVATION / DEPTH TOP OF SCREEN: /13'7
TYPE OF SCREEN: SLOT
SLOT SIZE x LENGTH: .010" x 10'
I.D. OF SCREEN: 4"
TYPE OF SAND PACK: NOD Sand/Gravel
ELEVATION / DEPTH BOTTOM OF SCREEN: /23
ELEVATION / DEPTH BOTTOM OF SAND PACK: /24
TYPE OF BACKFILL BELOW OBSERVATION WELL: Sand Pack / No Back Fill
ELEVATION / DEPTH OF HOLE: /24'

* BACKFILL TO BE INSTALLED WHEN DRILLERS RECEIVE MATERIALS 9-12-91 @ 1435

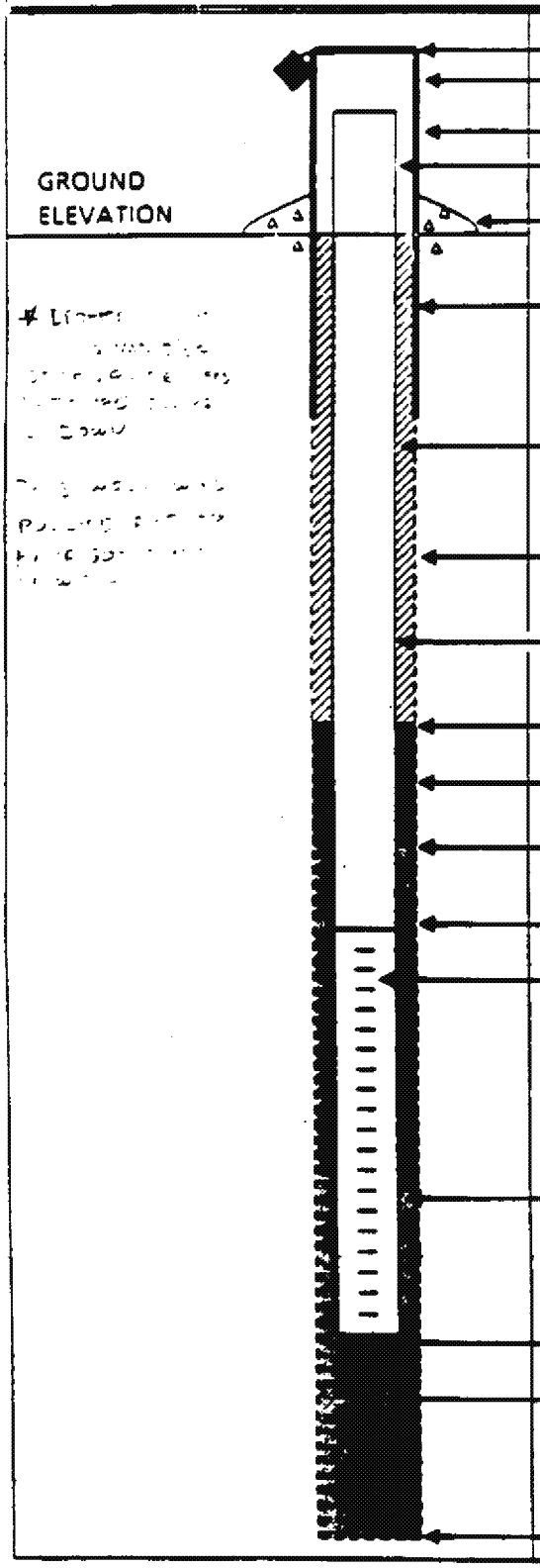
NUS CORPORATION
A Halliburton Company

BORING NO. MW-33

OVERBURDEN
MONITORING WELL SHEET

PROJECT
PROJECT NO.
ELEVATION
FIELD GEOLOGIST
LOCATION
BORING MW-33
DATE

DRILLER
DRILLING METHOD
DEVELOPMENT METHOD



ELEVATION OF TOP OF SURFACE CASING:
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE :
TYPE OF SURFACE SEAL:
I.D. OF SURFACE CASING:
TYPE OF SURFACE CASING:
RISER PIPE I.D.
TYPE OF RISER PIPE:
BOREHOLE DIAMETER:
TYPE OF BACKFILL:
ELEVATION / DEPTH TOP OF SEAL: 118'
TYPE OF SEAL:
DEPTH TOP OF SAND PACK: 120'
ELEVATION / DEPTH TOP OF SCREEN:
TYPE OF SCREEN: S.S.
SLOT SIZE x LENGTH: .010" x 10'
I.D. OF SCREEN: 4" ∅
TYPE OF SAND PACK:
ELEVATION / DEPTH BOTTOM OF SCREEN: 131'7"
ELEVATION / DEPTH BOTTOM OF SAND PACK:
TYPE OF BACKFILL BELOW OBSERVATION WELL:
ELEVATION / DEPTH OF HOLE: 132'

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BORING LOG

PROJECT Quantico — BORING NO MW-01
PROJECT NO.: 3261 — DATE: 9-13-91 — DRILLER: Badger
ELEVATION: — FIELD GEOLOGIST: A. Kendrick
WATER LEVEL DATA: 0 Hr. = 14.0' (±0.6')
(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS CLASS.	REMARKS
	1.0			1.0	loose	tan	Silt and clay, little sand (1. Mic grained)	ML	Fill (Disturbed)
	2.0				Stiff	red orange brown	Silt and clay, trace	ML	
	3.0						v. fine sand, sl. damp.		
	4.0								
	5.0								
S-1 5.0-7.0		3 6					"		Spoon = 7 ppm
0910		7 10	2.0/2.0						H.S = 10 ppm
	10.0			10.0					
S-2 10.0-12.0		3 7			v. stiff to hard	red brown tan	Silt and clay - some fabric to material	ML	Spoon = 6 ppm
0915		7 12	2.0/2.0				Saprolitic		H.S. = 10 ppm
							damp seams		
	15.0			15.0					
S-3 15.0-17.0		10 21			hard	Hard red brn. w/green	Chlorite/Mica Schist	VB	Spoon = 7 ppm
0920		20 45	2.0/2.0				highly weathered - decomposed		H.S = 12 ppm Auger H.S = 5 ppm
							diag. fractured, dk. brn. partings		H_2O @ 14.0' at 10 (9:25 - 9:39)
							wet @ top of rock (15')		
	20.0						damp by 17'		
S-4 20.0-22.0		26 36					End std. drilling @ 21.0'.		Spoon = 0.5 ppm
0945		40 50	2.0/2.0				Overdrill to set screen		H.S = 6 ppm
							to 25.0'.		
							Set well 11.0' - 21.0'		
	25.0						Sand = 9b Pellets = 7.0'		

REMARKS: Set Monitoring Well

BORING MW-

PAGE 1

APPENDIX C

C-DEMO OB/OD SITE SAMPLING RESULTS (1991) COMPARISON

TABLE C-1

INORGANICS DETECTED IN SOIL SAMPLES VERSUS BASEWIDE BACKGROUND AND SCREENING CRITERIA
C-DEMO OB/OD SITE
MCCDC, QUANTICO, VIRGINIA

Chemical	Maximum Soil Concentration (mg/kg)	Representative Basewide Background Concentration[1] (mg/kg)	Risk-Based Concentrations (mg/kg)[2]		Soil Screening Levels, Soil to Groundwater Migration (mg/kg)[2]	
			Industrial	Residential	DAF-1	DAF-20
Aluminum	27,600	26,300 - 27,200 (33,500)	2.0E6	7.8E4	-	-
Antimony	<2.4[3]	1.3 (3.1)	8.2E2	3.1E1	6.8E-1	1.3E1
Arsenic	4.5	12.3 (25.4)	3.8E0	4.3E-1	1.3E-3	2.6E-2
Barium	263	139 (182)	1.4E5	5.5E3	1.1E2	2.1E3
Beryllium	4.5	1.5 (1.5)	4.1E3	1.6E2	5.8E1	1.2E3
Cadmium	5.2	0.36 (0.57)	1.0E3	3.9E1	1.4E0	2.7E1
Calcium	400	660 - 1,520 (1,520)	-	-	-	-
Chromium	57.3	75.2 (88.9)	3.1E6 (III) 6.1E3 (VI)	1.2E5 (III) 2.3E2 (VI)	9.9E7 (III) 2.1E0 (VI)	2.0E9 (III) 4.2E-1 (VI)
Cobalt	3.7	26.0 (33.3)	1.2 E5	4.7E3	-	-
Copper	268	49.6 (62.2)	8.2E4	3.1E3	5.3E2	1.1E4
Iron	42,500	58,300 - 63,400 (63,400)	6.1E5	2.3E4	-	-
Lead	407	23.7 (32.0)	1.0E3[4]	4.0E2[4]	-	-
Magnesium	961	4,810 - 6,150 (6,720)	-	-	-	-
Manganese	133	1130 - 2170	4.1E4	1.6E3	4.8E1	9.5E2
Mercury	<0.14[3]	0.08 (0.18)	-	-	-	-
Nickel	7.2	35.5 (70.0)	4.1E4	1.6E3	-	-
Potassium	635	3,230 - 4,101 (7,080)	-	-	-	-
Selenium	0.59	1.4 - 2.4	1.0E4	3.9E2	9.5E-1	1.9E1
Silver	4.1	ND	1.0E4	3.9E2	1.6E0	3.1E1
Sodium	42	294 – 315 (341)	-	-	-	-
Thallium	<0.44[3]	1.6 (2.2)	1.4E2	5.5E0	1.;8E-1	3.6E0
Vanadium	80.8	109 (151)	1.4E4	5.5E2	2.6E2	5.1E3
Zinc	488	85.5 (85.5)	6.1E5	2.3E4	6.8E2	1.4E4

DAF = Dilution attenuation factor: DAF 1 applicable to site with shallow groundwater tables or source size greater than 30 acres. DAF-20 applicable as a default for other site conditions.

1 Maximum background concentration in parentheses.

2 USEPA - Region III Risk-Based Concentration Table (April 13, 2000).

3 < - Not detected at the detection limit.

4 Based on USEPA - Region 9 Preliminary Remediation Goals (May 2000).

TABLE C-2

INORGANICS DETECTED IN SOIL TCLP SAMPLES
C-DEMO OB/OD SITE
MCCDC, QUANTICO, VIRGINIA

Chemical	Maximum Soil TCLP Concentration (µg/L)	TCLP Criteria (µg/L)
Aluminum	1,500	NA
Antimony	<170[1]	NA
Arsenic	<30	5,000
Barium	574	100,000
Beryllium	<20	NA
Cadmium	230	1,000
Calcium	4,670	NA
Chromium	<40.0[1]	5,000
Cobalt	<50.0[1]	NA
Copper	2,740	NA
Iron	<60[1]	NA
Lead	14,300 (HS1)[2]	5,000
Magnesium	3,160	NA
Manganese	399	NA
Mercury	<10[1]	200
Nickel	97.7	2,000
Potassium	4,830	NA
Selenium	<30[1]	1,000
Silver	<20.0[1]	5,000
Sodium	1,480,000	NA
Thallium	<30[1]	NA
Vanadium	<30[1]	NA
Zinc	13,300	NA

1 < - Not detected at the detection limit.

2 Sample location for exceedence of lead TCLP criterion.

TABLE C-3

EXPLOSIVES DETECTED IN SOIL SAMPLES
C-DEMO OB/OD SITE
MCCDC, QUANTICO, VIRGINIA

Chemical	Maximum Soil Concentration (mg/kg)	Risk-Based Concentrations (mg/kg)[1]		Soil Screening Levels, Soil to Groundwater Migration (mg/kg)[1]	
		Industrial	Residential	DAF-1	DAF-20
Cyclotetramethylenetetranitramine (HMX)	<1.81[2]	1.0E5	3.9E3	-	-
Cyclotrimethylenetrinitramine (RDX)	<1.40[2]	8.2E3	3.1E2	-	-
1,3-Dinitrobenzene	<0.84[2]	2.0E2	7.8E0	1.8E-2	3.7E-2
2,4-Dinitrotoluene	2.42	4.1E3	1.6E2	2.9E-2	5.7E-1
2,6-Dinitrotoluene	<0.57[2]	2.0E3	7.8E1	1.2E2	2.5E-1
Nitrobenzene	<0.60[2]	1.0E3	3.9E1	1.2E-3	2.3E-2
1,3,5-Trinitrobenzene	<2.98[2]	6.1E4	2.3E3	-	-
Trinitrophenylmethylnitramine (Tetryl)	<7.14[2]	2.0E4	7.8E2	-	-
2,4,6-Trinitrotoluene	<2.74[2]	1.9E2	2.1E1	-	-

DAF = Dilution attenuation factor: DAF 1 applicable to site with shallow groundwater tables or source size greater than 30 acres. DAF-20 applicable as a default for other site conditions.

1 USEPA - Region III Risk-Based Concentration Table (April 13, 2000).

2 < - Not detected at the detection limit.

TABLE C-4

INORGANICS DETECTED IN GROUNDWATER SAMPLES
C-DEMO OB/OD SITE
MCCDC, QUANTICO, VIRGINIA

Chemical	Maximum Concentrations (µg/L)		SDWA MCL or VADEQ ACL (µg/L)
	Filtered	Unfiltered	
Aluminum	116	15,600	-
Antimony	<17.0[1]	<17.0[1]	6.3E0[2]
Arsenic	<3.0[1]	<3.0[1]	5.0E1[3]
Barium	203	219	2.0E3[3]
Beryllium	<2.0[1]	2.0	4.0E0[3]
Cadmium	<5.0[1]	<5.0[1]	5.0E0[3]
Calcium	24,200	23,000	-
Chromium	4.4	74.4	1.0E2[3]
Cobalt	<5.0[1]	28.4	9.4E2[2]
Copper	5.5	652	1.3E3[3]
Iron	202	55,300	1.1E4[4]
Lead	<2.0[1]	5.3	1.5E1[3]
Magnesium	10,100	9,530	-
Manganese	151	1,370	7.3E2[4]
Mercury	<0.2[1]	<0.2[1]	2.0E0[3]
Nickel	13.4	39.8	3.1E2[2]
Potassium	8,440	7,200	-
Selenium	<3.0[1]	<3.0[1]	5.0E1[3]
Silver	<2.0[1]	<2.0[1]	7.8E1[2]
Sodium	26,500	24,700	-
Thallium	<3.0[1]	<3.0[1]	2.0E0[3]
Vanadium	<3.0[1]	99.5	1.1E2[2]
Zinc	24.0[1]	111	4.6E3[2]

DAF = Dilution attenuation factor: DAF 1 applicable to site with shallow groundwater tables or source size greater than 30 acres. DAF-20 applicable as a default for other site conditions.

1 < - Not detected at the detection limit (DL) shown (maximum DL).

2 Virginia Department of Environmental Quality Alternate Concentration Limit, September 10, 1999 Memorandum.

3 Safe Drinking Water Act Maximum Contaminant Level.

4 US Environmental Protection Agency Risk – Based Concentration, April 13, 2000.

TABLE C-5

EXPLOSIVES DETECTED IN GROUNDWATER/SURFACE WATER SAMPLES
C-DEMO OB/OD SITE
MCCDC, QUANTICO, VIRGINIA

Chemical	Maximum Concentrations (µg/L)		VADEQ ACL or Region III RBC (µg/L)
	Filtered	Unfiltered	Tap Water
Cyclotetramethylenetetranitramine (HMX)	<1.3[1]	<1.3[1]	1.8E3[2]
Cyclotrimethylenetrinitramine (RDX)	<0.63[1]	<0.63[1]	6.1E-1[2]
1,3-Dinitrobenzene	<0.61[1]	<0.61[1]	1.6E0[3]
2,4-Dinitrotoluene	<60[1]	<0.60[1]	3.1E1[2]
2,6-Dinitrotoluene	<0.55	<0.55[1]	1.6E1[3]
Nitrobenzene	<1.69[1]	<1.13[1]	7.8E0[3]
1,3,5-Trinitrobenzene	<0.56[1]	<0.56[1]	4.7E2[3]
Trinitrophenylmethylnitramine (Tetryl)	2.47	<0.66[1]	3.7E2[2]
2,4,6-Trinitrotoluene	<0.78[1]	<0.78[1]	2.2E0[2]

1 < - Analyte not detected above detection limit shown.

2 USEPA - Region III Risk-Based Concentration Table (April 13, 2000).

3 VADEQ Alternate Concentration Limit, September 10, 1999 Memorandum.

TABLE C-6

COMPARISON OF UPGRADIENT AND DOWNGRADIENT GROUNDWATER CONCENTRATIONS FOR THE CONTAMINANTS OF CONCERN IDENTIFIED IN THE DRAFT FINAL CLOSURE PLAN (MARCH 1992) C-DEMO OB/OD SITE MCCDC, QUANTICO, VIRGINIA

Well No.	Upgradient Well (MW01)		Downgradient Well (MW02 or MW03)	
Chemical	Maximum Groundwater Unfiltered (µg/L)	Maximum Groundwater Filtered (µg/L)	Maximum Groundwater Unfiltered (µg/L)	Maximum Groundwater Filtered (µg/L)
Beryllium	2.0	2.0 U	2.0 U	2.0 U
Aluminum	12,300	68.0 B	15,600	116
Iron	29,600	87.0 B	55,300	202
Lead	4.8	2.0 U	5.3	2.0 U
Tetryl	2.4	--	2.47	--

B - Not detected substantially above the level reported in the lab or field blanks.

U - Not detected. The associated number indicates sample concentration necessary to be detected.

TABLE C-7

INORGANICS DETECTED IN SURFACE WATER SAMPLES
C-DEMO OB/OD SITE
MCCDC, QUANTICO, VIRGINIA

Chemical	Maximum Surface Water Concentration (µg/L)	SDWA MCL OR VADEQ ACL (µg/L)
Aluminum	1,420	-
Antimony	<17.0[1]	6.3E0[2]
Arsenic	<3.0[1]	5.0E1[3]
Barium	113	2.0E3[3]
Beryllium	<2.0[1]	4.0E0[3]
Cadmium	<5.0[1]	5.0E0[3]
Calcium	5,380	-
Chromium	<4.0[1]	1.0E2[3]
Cobalt	<5.7[1]	9.4E2[2]
Copper	7.1	1.3E3
Iron	7,610	1.1E4[4]
Lead	9.1	1.5E1[3]
Magnesium	3,400	-
Manganese	954	7.3E2[3]
Mercury	<0.2[1]	2.0E0[3]
Nickel	<8.0[1]	3.1E2[2]
Potassium	1,540	-
Selenium	<3.0[1]	5.0E1[3]
Silver	<2.0	7.8E1[2]
Sodium	3,750	-
Thallium	<3.0[1]	2.0E0[3]
Vanadium	<3.0[1]	1.1E2[2]
Zinc	35.6	4.6E3[2]

1 < - Analyte not detected at the detection above detection limit shown.

2 Virginia Department of Environmental Quality Alternate Concentration Limit, September 10, 1999 Memorandum.

3 Safe Drinking Water Act Maximum Contaminant Level.

4 US Environmental Protection Agency Risk – Based Concentration, April 13, 2000.

TABLE C-8

INORGANICS DETECTED IN SEDIMENT SAMPLES
C-DEMO OB/OD SITE
MCCDC, QUANTICO, VIRGINIA

Chemical	Maximum Soil Concentration (mg/kg)	Risk-Based Soil Concentrations (mg/kg)[1]		Soil Screening Levels, Soil to Groundwater Migration (mg/kg)[1]	
		Industrial	Residential	DAF-1	DAF-20
Aluminum	22,600	2.0E6	7.8E4	-	-
Antimony	<3.5[2]	8.2E2	3.1E1	6.8E-1	1.3E1
Arsenic	3.3	3.8E0	4.3E-1	1.3E-3	2.6E-2
Barium	190	1.4E5	5.5E3	1.1E2	2.1E3
Beryllium	2.0	4.1E3	1.6E2	5.8E1	1.2E3
Cadmium	<1.0[2]	1.0E3	3.9E1	1.4E0	2.7E1
Calcium	2,530	-	-	-	-
Chromium	101	3.1E6 (III) 6.1E3 (VI)	1.2E5 (III) 2.3E2 (VI)	9.9E7 (III) 2.1E0 (VI)	2.0E9 (III) 4.2E-1 (VI)
Cobalt	15.4	1.2 E5	4.7E3	-	-
Copper	80.9	8.2E4	3.1E3	5.3E2	1.1E4
Iron	94,800	6.1E5	2.3E4	-	-
Lead	60.9	1.0E3[3]	4.0E2[3]	-	-
Magnesium	3,220	-	-	-	-
Manganese	747	4.1E4	1.6E3	4.8E1	9.5E2
Mercury	<0.25[2]	-	-	-	-
Nickel	19.8	4.1E4	1.6E3	-	-
Potassium	1,300	-	-	-	-
Selenium	0.39	1.0E4	3.9E2	9.5E-1	1.9E1
Silver	<0.41[2]	1.0E4	3.9E2	1.6E0	3.1E1
Sodium	116	-	-	-	-
Thallium	<0.72[2]	1.4E2	5.5E0	1.;8E-1	3.6E0
Vanadium	126	1.4E4	5.5E2	2.6E2	5.1E3
Zinc	136	6.1E5	2.3E4	6.8E2	1.4E4

DAF = Dilution attenuation factor: DAF 1 applicable to site with shallow groundwater tables or source size greater than 30 acres. DAF-20 applicable as a default for other site conditions.

1 USEPA - Region III Risk-Based Concentration Table (April 13, 2000).

2 < - Not detected at the detection limit (DL) shown (maximum DL).

3 Based on USEPA - Region 9 Preliminary Remediation Goals (May 2000)

TABLE C-9

EXPLOSIVES DETECTED IN SEDIMENT SAMPLES
C-DEMO OB/OD SITE
MCCDC, QUANTICO, VIRGINIA

Chemical	Maximum Sediment Concentration (mg/kg)	Risk-Based Soil Concentrations (mg/kg)[1]		Soil Screening Levels, Soil to Groundwater Migration (mg/kg)[1]	
		Industrial	Residential	DAF-1	DAF-20
Cyclotetramethylenetetranitramine (HMX)	<2.56[2]	1.0E5	3.9E3	-	-
Cyclotrimethylenetrinitramine (RDX)	<1.97[2]	8.2E3	3.1E2	-	-
1,3-Dinitrobenzene	<1.19[2]	2.0E2	7.8E0	1.8E-2	3.7E-2
2,4-Dinitrotoluene	<0.85[2]	4.1E3	1.6E2	2.9E-2	5.7E-1
2,6-Dinitrotoluene	<0.80[2]	2.0E3	7.8E1	1.2E2	2.5E-1
Nitrobenzene	<0.85[2]	1.0E3	3.9E1	1.2E-3	2.3E-2
1,3,5-Trinitrobenzene	<4.21[2]	6.1E4	2.3E3	-	-
Trinitrophenylmethylnitramine (Tetryl)	<10.1[2]	2.0E4	7.8E2	-	-
2,4,6-Trinitrotoluene	<3.86[2]	1.9E2	2.1E1	-	-

DAF = Dilution attenuation factor: DAF 1 applicable to site with shallow groundwater tables or source size greater than 30 acres. DAF-20 applicable as a default for other site conditions.

1 USEPA - Region III Risk-Based Concentration Table (April 13, 2000).

2 < - Not detected at the detection limit shown.

APPENDIX D

SAMPLING AND ANALYSIS PLAN

APPENDIX D

SAMPLING AND ANALYSIS PLAN

At the initiation of final closure a sampling and analysis program will be conducted to provide site characterization data to evaluate the nature and extent of contamination. This will involve sampling and analysis of the following media at the C-Demo OB/OD site:

- Surface and subsurface soils;
- Surface water and sediment (including onsite swales as applicable); and
- Groundwater.

A modification to the technical approach presented in this Sampling and Analysis Plan may be warranted at final closure because of advances in site characterization and analytical methods. Revision to the Sampling and Analysis Plan would be addressed, as necessary, in an amendment to this Closure Plan.

D.1 TARGET ANALYTES

The target analytes and associated SW-846 analytical methods for the sampling program at final closure of the C-Demo OB/OD site are identified in Table D-1. This list is based on the primary constituents of waste munitions and potential OB/OD treatment emissions as discussed in Section 3.0 of the Closure Plan. These target analytes also include those constituents that exceeded screening criteria (i.e., 2,4-DNT, arsenic, barium, cadmium, chromium, iron, lead, manganese, and silver) as well as total metals that were detected at concentrations greater than background during the preliminary site investigations of the C-Demo OB/OD site (1991). Practical quantitation levels (PQLs) for target analytes (commensurate with SW 846 analytical methods) will be specified by the laboratory selected at final closure for analytical support. In general, the analytical methods have been selected so that associated PQLs will be lower than the lowest expected concentration of the constituent in the samples and/or constituent-specific risk-based criteria. The analytical lab to be selected at final closure will have developed and will follow QA/QC procedures recommended in SW 846.

D.2 SAMPLING STRATEGY

D.2.1 Soil Sampling Strategy

A total of 20 soil sampling locations will be used. This will include five local background sampling locations (outside of but nearby the C-Demo area to facilitate statistical analyses as discussed in

TABLE D-1

TARGET CONSTITUENTS FOR SOIL AND GROUNDWATER
MCCDC, QUANTICO, VIRGINIA
PAGE 1 OF 2

Parameter	USEPA method no.[1]	Matrix[2]
Semivolatile organics	SW-846 8270C (Extraction - 3510C or 3520C) SW-846 8270C (Extraction - 3540C or 3550B)	Aqueous Soil
Volatile organics (only as warranted based on PID field screening measurements)	SW-846 8260B (low level) SW-846 8260B	Aqueous Soil
Total metals:[3, 12]		Aqueous (unfiltered/unfiltered)) Soil
Aluminum	SW-846 6010B	
Antimony	SW-846 6010B	
Arsenic	SW-846 6010B	
Barium	SW-846 6010B	
Beryllium	SW-846 6010B	
Cadmium	SW-846 6010B	
Chromium	SW-846 6010B	
Cobalt	SW-846 6010B	
Copper	SW-846 6010B	
Iron	SW-846 6010B	
Lead	SW-846 6010B	
Manganese	SW-846 6010B	
Magnesium	SW-846 6010B	
Nickel	SW-846 6010B	
Selenium	SW-846 6010B	
Silver	SW-846 6010B	
Tin	SW-846 6010B	
Vanadium	SW-846-6010B	
Zinc	SW-846 6010B	
TCLP metals[4] (As, Ba, Cd, Cr, Pb, Hg, Se, Ag)	SW-846 1311/6010B/7000A Series[5]	Soil
TCLP semivolatile Organics[6]	SW-846 1311 (extraction) 3510B/3520B (extraction) 8270C (analysis)	Soil
Cyanide[7] (total)	SW-846 9010B	Aqueous Soil
Sulfides[8] (total)	SW-846 9030B	Aqueous Soil
Phosphorus (total)	SW-846 365.1, 2 or 3	Aqueous
Energetics[9]	SW-846 8330/8332	Aqueous Soil
Dioxins/furans (trench locations only)	SW-846 8290	Soil
Nitrates+nitrites	USEPA 353.3[10]	Aqueous Soil
Total organic carbon	Modified USEPA 415.1 Walkey Black[11]	Soil
PH	SW-846 9045C	Aqueous Soil

TABLE D-1

TARGET CONSTITUENTS FOR SOIL AND GROUNDWATER
MCCDC, QUANTICO, VIRGINIA
PAGE 2 OF 2

[1]USEPA *Test Methods for Evaluating Solid Wastes*, SW-846, Third Edition, Final Update III Dec. 1996.

[2]Matrix spike/matrix spike duplicate (MS/MSD) analyses for volatile organic compound and semivolatile organic compound analyses are to be performed at a frequency of one MS/MSD analysis per 20 samples. Likewise, matrix spike (MS) and laboratory duplicate (LD) analyses for the inorganic fraction analyses are to be performed at a frequency of one MS and LD analyses per 20 samples.

[3]For the 6010B analyses, preparation methods 3005A or 3010A are applicable for water samples, whereas 3050B is applicable for soil samples. Method 3050B is also applicable for soil samples for preparation of samples undergoing analysis by the Inductively Coupled Plasma (axial) 7000A series methods.

[4]TCLP analyses will be completed only if total metal analyses results indicate that RCRA regulatory levels are exceeded by a factor of 20 as follows:

- Arsenic 5.0 mg/kg x 20 = 100 mg/kg
- Barium 100.0 mg/kg x 20 = 2,000 mg/kg
- Cadmium 1.0 mg/kg x 20 = 20 mg/kg
- Chromium 5.0 mg/kg x 20 = 100 mg/kg
- Lead 5.0 mg/kg x 20 = 100 mg/kg
- Mercury 0.2 mg/kg x 20 = 4 mg/kg
- Selenium 1.0 mg/kg x 20 = 20 mg/kg
- Silver 5.0 mg/kg x 20 = 100 mg/kg

[5]The 7000A Series analyses include mercury (7470A).

[6]TCLP analysis will be completed only if semivolatile organic analyses results indicate that RCRA regulatory levels are exceeded by a factor of 20 (e.g., for nitrobenzene: 2.0 mg/kg x 20 = 40 mg/kg).

[7]The method described in SW-846 Section 7.3.3.2 (Test Method to Determine Hydrogen Cyanide Released from Wastes) will be used to prepare soil samples. The extract will be analyzed using method 9010B.

[8]The method described in SW-846 Section 7.3.4.2 (Test Method to Determine Hydrogen Sulfide Released from Wastes) will be used to prepare soil samples. The extract will be analyzed using method 9030B.

[9]The following energetics are to be analyzed using Method 8330:

- HMX
- RDX
- TNT
- Tetryl
- 1,3,5-Trinitrobenzene
- Nitrobenzene
- 1,3-Dinitrobenzene
- 2-Amino,4,6-Dinitrotoluene
- 4-Amino,4,6-Dinitrotoluene
- 2,4-DNT
- 2,6-DNT
- Ortho nitrotoluene
- Meta nitrotoluene
- Para nitrotoluene
- 3,5-Dinitroaniline (degradation product) (LC/MS modified 8330)
- Nitroglycerine (SW-846 8332)

Note: 3,5-Dinitroaniline will be run using a modified Method 8330, e.g., liquid chromatography/mass spectroscopy.

[10]USEPA, March 1979, Methods for Chemical Analysis of Water and Wastes, USEPA - 600/4-799-020, revised March 1983.

[11]The modified USEPA Method 415.1 (also referred to as the Walkey Black method) will be used for analyzing total organic carbon in soils.

[12]Calcium, magnesium, potassium, and sodium are not included because risk-based health criteria are not available for the common nutrients.

Appendix E of the Closure Plan) and 15 within the C-Demo OB/OD site. (Available basewide soil background data will also be used for statistical analyses and comparison purposes). The general locations of the background soil locations will be approximately 100 meters outside of the C-Demo area in a variety of directions to provide spatial variability. The background samples will be representative of the soil strata at the C-Demo OB/OD site. These locations will be selected to characterize the background adjacent to the C-Demo area and facilitate sampling access (i.e., near access roads).

Approximately five sampling locations will be randomly selected within "hot spot" areas (e.g., buried pits and/or trenches) as identified by the geophysical investigations to conducted (as discussed in Section 4.3 of the Closure Plan). The other 10 soil sampling locations will be randomly selected within the C-Demo OB/OD site but outside of the "hot spot" areas. A random number generator as described in USEPA SW-846, Chapter 9, will be used to select the sampling locations. A sampling grid with 50-feet spacing will be used to selected the random sampling locations. Surface soil samples will be collected from 0-6 inches below the ground surface at each sampling location.

Subsurface soil samples will be obtained only in the "hot spot" areas and those locations that surface soil concentrations exceeded screening criteria. Subsurface soil samples will be collected at depth sufficient to document the vehicle extend of contamination.

Verification sampling would also be needed after soil excavation (if necessary) to demonstrate compliance with risk-based cleanup standards. For verification sampling, two approaches are currently, and widely, used. This first approach involves taking a minimum of one sampling from each wall of the excavation pit. Under this approach, all four walls are treated as one entity, and an evaluation of the wall sampling results would have the same impact on all four walls. With the second approach, a minimum of four samples for each wall is collected. Then each wall is evaluated separately to determine whether the sampling results for each wall satisfy the performance standards. The approach (from the alternatives identified above) to be used at final closure will be at the discretion of MCCDC Quantico. However, the target analytes for verification sampling will be limited to only those HCOCs needed to demonstrate compliance with risk-based cleanup standards.

D.2.2 Surface Water and Sediment Sampling

Surface water and sediment samples will be collected from one to five locations (as warranted). These locations will be selected at final closure based on a site inspection to identify nearby drainage swales and surface water drainage pathways.

D.2.3 Groundwater Sampling

The existing groundwater monitoring wells (one upgradient and three downgradient) from the preliminary investigation (1991) at the C-Demo OB/OD site will be resampled at final closure. These results will be submitted to VADEQ and the need for additional sampling/wells will be evaluated. A separate Groundwater Monitoring Plan would be prepared as necessary.

D.3 SAMPLING PROTOCOLS

All samples collected during closure activities (soil, water, and waste) will be collected in general compliance with currently acceptable industry standards to ensure, at a minimum, the following concerns are addressed: cross-contamination, representativeness, and data quality assurance/quality control (QA/QC). All samples collected must be handled in accordance with Section D.4 and each sample event must adhere to the QA/QC procedures discussed in Section D.5.

Soil samples will be collected using a hand auger, hollow stem auger, or similar method. Before initiating collection activities and between each sample collected, a thorough decontamination cycle must be performed.

D.4 SAMPLE HANDLING

All samples will be labeled to prevent misidentification in the field and at the laboratory. Sample labels will include at least the following information:

- Site Name
- Sample Number
- Name of Collector
- Data and Time of Collection
- Preservative
- Type of Sample (Grab or Composite)
- Sample Matrix
- Analytical Method

Labels will be affixed to the sample containers before or at the time of collection and will be filled out in indelible ink at the time of collection. Custody seals will be used to prevent unauthorized tampering of samples following collection and up to the time of analysis. The seal will contain the identical information as it appears on the sample label. The seal will be affixed in such a way that it is necessary to break the seal to open the sample container. Seals will be affixed to the sample containers before the samples leave the custody of sampling personnel. The chain-of-custody record for a given sample is to be completed before sampling is initiated by the same sampling team at other locations.

The samples will be placed in coolers and preserved according to USEPA protocol while en-route to the laboratory for analysis. Chain-of-custody forms will be used to document transfer of samples from the collector to the transporter to the analytical laboratory. All information and documentation pertinent to field sample will be recorded in a field file or logbook. Sample locations will be marked on site plans and entered into the field file.

D.5 QUALITY ASSURANCE/QUALITY CONTROL

Field sampling QA/QC procedures will include the collection of Equipment Blanks, Trip Blanks, Field Blanks, and Field Duplicates. Equipment Blanks will be used to indicate whether incomplete decontamination of equipment or cross-contamination has occurred. Trip Blanks will accompany sample containers to and from the field. These samples will be used to detect any contamination or cross-contamination during handling and transportation. Field Blanks will be collected and analyzed to detect any contamination from sampling equipment or cross-contamination between sampling locations. Field Duplicate samples will be collected randomly at designated sample locations. These samples will be analyzed by an independent qualified laboratory and samples will be used to document any variances in analytical technique from the primary laboratory. Documentation of the QA/QC sampling and analyses will be conducted per USEPA SW-846, Chapter 1, and submitted to VADEQ along with the final closure Sampling and Analysis Report.

D.6 DECONTAMINATION OF SAMPLING EQUIPMENT

Decontamination of reusable sampling equipment will be commensurate with OSWER Directive 9360.4-07, "Compendium of ERT Waste Sampling Procedures," January 1991. A summary of the decontamination procedure follows:

- Where applicable, physically remove the material from the sampling equipment using a mechanical means involving metal or nylon brushes, or high pressure water.
- Wash the equipment with a nonphosphorous detergent solution.
- Rinse with tap water.
- Rinse with distilled/deionized water.
- Rinse with 10 percent nitric acid if the sample will be analyzed for trace metals.

- Rinse with distilled/deionized water.
- Rinse with pesticide grade solvent (acetone or hexane) if the sample will be analyzed for trace organics.
- Rinse with distilled/deionized water.
- Air dry the equipment completely.

In addition, the following measures will be implemented:

- A designated decontamination area will be established before soil sampling. This area will be lined with an impervious plastic layer. At the end of the sampling event, the area will be cleaned.
- The decontamination water generated will be stored in clean containers in a designated area onsite. The decontamination water will be managed as IDW.
- Except for the disposable items, all reusable sampling equipment will be decontaminated before use in the field, between each sample, and upon completion of all sampling activities.

D.7 SAMPLING AND ANALYSIS DOCUMENTATION

At the conclusion of the sampling and analysis program at final closure the results will be documented in the Closure Report and submitted to VADEQ. This Closure Report will include the following sampling and analysis program information:

- Site characterization summary
- Sampling program
- Analytical program
- Quality assurance program
- Hydrogeological evaluation
- Analytical data validation
- Statistical analyses
- Risk-based cleanup goals

The technical approach for statistical analyses and development of risk-based cleanup goals is discussed in Appendix E of the Closure Plan.

APPENDIX E

RISK ASSESSMENT PROTOCOL

APPENDIX E
RISK ASSESSMENT PROTOCOL

Risk-based closure standards will be established for HCOCs that are significant compared with background and exceed USEPA Region III Risk-Based Concentrations or applicable groundwater evaluation criteria. The risk-based closure standards will ensure the following:

- Total cumulative Hazard Index (HI) of 1.0 or less for noncarcinogens:
- Total cancer risk in the range of 1E-04 to 1E-06 for individual carcinogens;
- Total cancer risk of 1E-04 or less for all carcinogens; and
- Concentrations of HCOCs remaining at the site will not result in contamination of other environmental media of concern, including the groundwater underneath the unit.

The risk assessment protocol to be used for the implementation of these standards is based on current VADEQ guidance. A modification to this technical approach may be warranted at final closure because of potential updates to VADEQ guidance. These revisions to the risk assessment protocol would be addressed, as necessary, in an amendment to the Closure Plan.

Compliance with the closure standard may be verified by comparing the concentration of each of the HCOCs that fails background comparison with the risk-based cleanup goals. To estimate the risks presented by the chemicals, a risk assessment shall be conducted in accordance with VADEQ's Guidance Document and Submission Package for Site Remediation and Cleanup Using Health-Based Standards – Risk Exposure and Analysis Modeling System (REAMS), November 1, 1994.

The principal components of the REAMS evaluation are the following:

- Site evaluation
- Development of a site conceptual exposure model
- Statistical analyses and identification of HCOCs for further evaluation
- Toxicity assessment
- Exposure assessment
- Evaluation of risk.

Future land use of the C-Demo OB/OD site after final closure is not known at this time. Therefore, initially, residential exposure will be assumed for the purpose of attempting to document unrestricted closure of the soil. If the residential soil cleanup goals are not exceeded, unrestricted closure of soil will have been documented. If the residential soil cleanup goals are exceeded, then the option to pursue restricted closure (commercial/industrial) will be exercised. Associated with the commercial/industrial exposure scenario would be the requirement to enact a deed restriction that eliminates the possibility of future residential use of the site. The requirements for establishing such a deed restriction are detailed in VADEQ's Guidelines for Developing Health-Based Cleanup Goals Using Risk Assessment at a Hazardous Waste Site Facility for Restricted Industrial Use, dated June 1995.

This risk assessment process and results will be documented in the Closure Report to be submitted to VADEQ upon completion of final closure. This information to be included will be commensurate with submission instructions contained in Appendix IX of the REAMS Guidance and information from the sampling and analysis program as identified in Appendix D.7 of the Closure Plan.

E.1 SITE EVALUATION AND SITE CONCEPUTAL EXPOSURE MODEL

The site evaluation input to the risk assessment will consist of results from the sampling and analysis program at final closure as well as identification of potential receptors (as a function of future land use). This information will be used to develop a site conceptual exposure model that depicts all potential exposure routes and media for the site and the receptors that may be exposed.

E.2 STATISTICAL ANALYSES AND IDENTIFICATION OF HCOCs FOR FURTHER EVALUATION

HCOC's selection for further evaluation involves the identification of those constituents detected in the final closure environmental samples that may be related to the use of previous waste management practices and whose concentrations exceed statistical background levels. If no contaminants are detected in the soil, it will be assumed that the site meets the requirements of unrestricted closure. VADEQ approval is required before such a conclusion is reached. If contaminants are detected in soil but they do not exceed background levels, no further risk-based evaluation will be required. Constituents of concern having concentrations that are statistically greater than background concentrations will be subject to REAMS evaluation to estimate the risks.

E.2.2 Statistical Analysis of Soils

The Wilcoxon Rank Sum Test will be used to evaluate the statistical significance of soil sampling results from the C-Demo OB/OD site compared with background data. If an alternate statistical test is warranted based on sampling results at final closure the approach selected will be commensurate with available VADEQ guidance.

The Wilcoxon rank Sum test is a nonparametric test used for comparison of the median of the background data with the median of the compliance data. The test assumes the distributions of the two datasets are the same. A minimum of five background samples and five compliance samples is needed to perform this test. The advantage of the Wilcoxon test is the small number of samples needed to perform the test. The disadvantage is that the test assumes uniform contamination exists at the site. Therefore, as indicated in Appendix D of the closure plan one set of samples will be collected within potential "hot spot" areas and the second set from the remainder of the C-Demo OB/OD site.

The sampling data from the C-Demo OB/OD site will be compared with local background (i.e., nearby but outside of the C-Demo area) as well as with available basewide background (i.e., 110 soil samples collected from 56 locations within MCCDC Quantico).

E.2.3 Statistical Analysis of Groundwater

Statistical analysis of groundwater data for final closure of the C-Demo OB/OD site will include the following:

- Outliers
- Testing of normality
- Missing data
- Evaluation of data below detection limits or quantitation limits
- Selection of statistical method
- Verification sampling strategy (optional)
- Comparison of compliance well data to a standard

The technical approach will be specified in the Groundwater Monitoring Plan (to be prepared before final closure) and will be commensurate with applicable VADEQ guidance at the time of final closure.

E.3 TOXICITY ASSESSMENT

The following toxicity value information sources and hierarchy will be used commensurate with the REAMS Guidance:

- USEPA Integrated Risk Information System (IRIS)
- USEPA Health Effects Assessment Summary Tables (HEAST)
- USEPA Environmental Criteria and Assessment Office
- Agency for Toxic Substances and Diseases Registry (ATSDR)

These information sources will be used to obtain updated HCOC-specific toxicity data at final closure.

The two principal indices of toxicity used in risk assessment are the chronic reference dose (RfD) and the chronic slope factor (CSF) for carcinogens. An RfD is the intake or dose per unit of body weight (mg/kg-day) that is unlikely to result in adverse (noncarcinogenic) effects to human populations, including sensitive subgroups (e.g., the very young or elderly). The RfD allows for the existence of a threshold dose below which no adverse effects occur. A related value, the reference concentration (RfC), is used to evaluate the noncarcinogenic health effects from inhalation exposure to chemicals of concern. The RfC is expressed in terms of mg/m^3. The RFC can be converted to an inhalation-specific RfD by assuming an inhalation rate of 20 m^3/day and a body weight of 70 kg.

The CSF is used to express the cancer risk attributable to a discrete unit of intake, that is, the cancer risk per milligram ingested per kilogram of body weight per day ($mg/kg\text{-}day^{-1}$). The CSF is an estimate of the upper-bound probability of an individual developing cancer as a result of exposure to a particular carcinogen. Unlike the RfD, the CSF assumes that there is no threshold dose below which the probability of developing cancer is zero. Note that CSFs are only developed for those chemicals that have been shown to be carcinogens in humans or in at least several animal species. A carcinogenic weight of evidence rating is used to describe the strength of the experimental evidence for carcinogenicity. USEPA has developed CSFs for most chemicals with weight of evidence ratings of "A" (known human carcinogen) or "B" (probable human carcinogen).

RfDs and CSFs are derived by the USEPA for the most toxic chemicals generally associated with chemical releases to the environment for which adequate toxicological data are available. If both the

carcinogenic and noncarcinogenic effects of a particular compound are significant, both values may be established. However, in most cases only one value is available.

E.4 EXPOSURE ASSESSMENT

This assessment will be used to quantify exposures that individuals may have to the HCOCs that are present at or potentially migrating from the site. The results of this assessment will be used to document the current and future exposure potential posed by the site.

Exposure routes will include ingestion, dermal absorption, and inhalation of vapors and dust particles as identified in the site conceptual exposure model. The formulas and default variable values are presented in Tables E-1 through E-4, commensurate with REAMS Guidance. Fate and transport modeling will be performed to assess residual soil contamination impacts to groundwater based on the REAMs Guidance.

As part of the REAMS evaluation, fate and transport modeling is necessary to demonstrate that the remaining concentrations of contaminants of concern in the soil will not result in contamination of other environmental media, including groundwater beneath the site. For modeling purposes, HCOC properties needed as input to REAMS will be based on site-specific data or appropriate default data based on site conditions.

E.5 EVALUATION OF RISKS

E.5.1 Human Health Cancer Risk

For carcinogenic chemicals, risk estimates represent the incremental probability that an individual will develop cancer over a lifetime as a result of a specific exposure to a carcinogenic chemical. These risks are calculated as follows:

$$Cancer\ Risk = LADD \bullet CSF \qquad \text{Equation E-1}$$

where

LADD = Lifetime average daily dose (mg/kg-day)
CSF = Cancer slope factor $(mg/kg\text{-}day)^{-1}$

TABLE E-1

EXPOSURE VARIABLES INCLUDED IN TABLES E-2 THRU E-4
MCCDC, QUANTICO, VIRGINIA
PAGE 1 OF 2

Symbol	Term	Unit	Value	Reference
ABS	Absorption factor	-	User specified	
AF	Adherence factor	-	1.45	a, c
AT_c	Averaging time carcinogens	days	25550	
AT_n	Averaging time noncarcinogens	days	ED x 365	
BW_a	Body weight adult	kg	70	c
BW_c	Body weight child	kg	15	c
CF	Conversion factor	-	0.000001	-
CS	Chemical concentration in soil	mg/kg-day	User specified	
CW	Chemical concentration in water	mg/L	User specified	
ED_c	Exposure duration child	Years	6	c
ED_{total} ED	Exposure duration for carcinogen total or residential	Years	30	c
ED^o	Exposure duration occupational	Years	25	c
EF	Exposure frequency residential	Days	350	c
ET	Exposure time General/occupational Groundwater Surface water – ingestion Surface water – dermal Air – inhalation	hrs/day	 8.0 0.2 2.6 2.6 24.0	c, d
FI	Fraction ingested Residential Occupational	-	 1.0 0.5	b
IRA_a	Inhalation rate air adult	m^3/day	20	b
IRA_{adj}	Inhalation rate – air adjusted	-	11.66	
IRA_c	Inhalation rate child	m^3/day	12	b
IRA_a	Inhalation rate adult	m3/day	20	b
IR	Ingestion rate food Fruit/veggies Fish	kg/day	0.28 0.122 0.054	c, d
IRS_a	Ingestion rate soil adult	mg/day	100	b
IRS_c	Ingestion rate soil child	mg/day	200	b
IRS_{adj}	Ingestion soil adjusted	-	114.29	
IRS_c	Ingestion rate soil child	mg/day	200	b
IRW_a	Ingestion rate water adult	L/day	2	b
IRW_{adj}	Ingestionwater adjusted	L-y/kg-d	1.09	
IRW_c	Ingestion rate water child	L/day	1	b

TABLE E-1

EXPOSURE VARIABLES INCLUDED IN TABLES E-2 THRU E-4
MCCDC, QUANTICO, VIRGINIA
PAGE 2 OF 2

Symbol	Term	Unit	Value	Reference
K	Volatilization factor, water to air	-	0.5	
PC	Permeability constant	cm/hr	User specified	b
PEF	Particulate emission factor	Kg/km3	6.789926E08	f
SAW_c	Surface area child Groundwater dermal Surface water dermal	cm^2	7500	b, e
	Surface area soil	cm^2/event		
SAS_a	Occupational-adult		4500	e
SAS_c	Child		1875	
SAS_{adj}	Surface area soil adjusted	cm^2/event	2290	
SAW_a	Surface area for water contact adult	cm^2	820	b
SAW_{adj}	Surface area for water contact	cm^2/event	9200	
VF	Volatilization factor, soil to air	kg/m^3	User specified	

References:

a. Risk Assessment Guidance for Superfund, Volume I, EPA/540/1-89/002, December 1989.

b. Region III values

c. Exposure Factors handbook, EPA/600/8-89-043, July 1989

d. Human health evaluation manual supplemental guidance, OSWER Directive 9285.6-03. March 25, 1991.

e. Dermal Exposure Assessment, Principles and Applications, Interim Report, EPA/600/8-91/011b. January 1992.

f. Technical Background Document for Draft Soil Screening Level Guidance. Office of Solid Waste and Emergency Response. EPA/540/R-94/101. December 1994.

TABLE E-2

RISK ASSESSMENT ALGORITHM FOR CARCINOGENIC EXPOSURE
MCCDC, QUANTICO, VIRGINIA

Exposure Route	Lifetime Average Daily Dose (mg/kg-day)	
	Residential Exposure	Occupational/ Industrial Exposure
Groundwater		
Ingestion	$\frac{CW \times IRW_{adj} \times EF}{AT_c}$	$\frac{CW \times IRW_a \times EF_o \times ED_o}{BW_a \times AT_c}$
Inhalation	$\frac{CW \times IRA_{adj} \times EF \times K}{AT_c}$	$\frac{CW \times IRA_a \times EF_o \times ED_o \times K}{BW_a \times AT_c}$
Dermal	$\frac{CW \times SAW_{adj} \times PC \times ET \times EF \times CF}{AT_c}$	$\frac{CW \times SAW_a \times PC \times ET \times EF_o \times ED_o \times CF}{BW_a \times AT_c}$
Soil		
Ingestion	$\frac{CS \times IRS_{adj} \times CF \times FI \times EF}{AT_c}$	$\frac{CS \times IR \times CF \times FI \times EF_o \times ED_o}{BW_a \times AT_c}$
Dermal	$\frac{CS \times CF \times SAS_{adj} \times AF \times ABS \times EF}{AT_c}$	$\frac{CS \times CF \times SAS_a \times AF \times ABS \times EF_o \times ED_o}{BW_a \times AT_c}$
Inhalation of vaporizing VOCs from soil	$\frac{CS \times IRS_{adj} \times EF}{AT_c \times VF}$	$\frac{CS \times IRA_a \times EF_o \times ED_o}{VF \times BW_a \times AT_c}$
Inhalation of emitting particles from soil	$\frac{CS \times EF \times IRS_{adj}}{AT_c \times PEF}$	$\frac{CS \times IRA_a \times EF_o \times ED_o}{PEF \times BW_a \times AT_c}$

TABLE E-3

RISK ASSESSMENT ALGORITHM FOR NONCARCINOGENIC EXPOSURE MCCDC, QUANTICO, VIRGINIA

Exposure Route	Lifetime Average Daily Dose (mg/kg-day)	
	Residential Exposure	Occupational/ Industrial Exposure
Groundwater		
Ingestion	$\frac{CW \times IRW_c \times EF \times ED_c}{BW_c \times AT_n}$	$\frac{CW \times IRW_a \times EF_o \times ED_o}{BW_a \times AT_n}$
Inhalation	$\frac{CW \times IRA_c \times EF \times ED_c \times K}{BW_c \times AT_n}$	$\frac{CW \times IRA_a \times EF_o \times ED_o \times K}{BW_a \times AT_n}$
Dermal	$\frac{CW \times SAW_c \times PC \times ET \times EF \times ED_c \times CF}{BW_c \times AT_n}$	$\frac{CW \times SAW_a \times PC \times ET \times EF_o \times ED_o \times CF}{BW_a \times AT_n}$
Soil		
Ingestion	$\frac{CS \times IRS_c \times CF \times FI \times EF \times ED_c}{BW_c \times AT_n}$	$\frac{CS \times IRS_a \times CF \times FI \times EF_o \times ED_o}{BW_a \times AT_n}$
Dermal	$\frac{CS \times CF \times SA_c \times AF \times ABS \times EF \times ED_c}{BW_c \times AT_n}$	$\frac{CS \times CF \times SA \times AF \times ABS \times EF_o \times ED_o}{BW_a \times AT_n}$
Inhalation of vaporizing VOCs from soil	$\frac{CS \times IR_c \times EF \times ED_c}{AT_c \times VF}$	$\frac{CS \times IR_a \times EF_o \times ED_o}{BW_a \times AT_n \times VF}$
Inhalation of emitting particles from soil	$\frac{CS \times IR_c \times EF \times ED_c}{BW_c \times AT_n \times PEF}$	$\frac{CS \times IR_a \times EF_o \times ED_o}{BW_a \times AT_n \times PEF}$

TABLE E-4

AGE-ADJUSTED FACTORS
MCCDC, QUANTICO, VIRGINIA

$$IRA_{adj} = \frac{ED_c \times IRA_c}{Bw_c} + \frac{(ED_{tot} - ED_c) \times IRA_a}{BW_a}$$

$$IRW_{adj} = \frac{ED_c \times IRW_c}{Bw_c} + \frac{(ED_{tot} - ED_c) \times IRW_a}{BW_a}$$

$$SAW_{adj} = \frac{ED_c \times SAW_c}{Bw_c} + \frac{(ED_{tot} - ED_c) \times SAW_a}{BW_a}$$

$$IRS_{adj} = \frac{ED_c \times IRS_c}{Bw_c} + \frac{(ED_{tot} - ED_c) \times IRS_a}{BW_a}$$

$$SAS_{adj} = \frac{ED_c \times SA_c}{Bw_c} + \frac{(ED_{tot} - ED_c) \times SA_a}{BW_a}$$

Note regarding age-adjusted factor:

Because contact rate with tap water, ambient air, and residential soil is different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors. These factors approximate the integrated exposure from birth until age 30 by combining contact rates, body weight, and exposure durations for two age groups – small children and adults.

Within a specific exposure pathway, receptors may be exposed to more than one COPC. The total risk associated with exposure to all HCOCs through a single exposure pathway is estimated as follows:

$$Total\ Cancer\ Risk_P = \sum_i Cancer\ Risk_i \qquad \text{Equation E-2}$$

where

Total Cancer $Risk_P$ = Total cancer risk for a specific exposure pathway
Cancer Risk $HCOC_i$ = Cancer risk $HCOC_i$ for a specific exposure pathway

At particular exposure scenario locations, receptors may be exposed through a number of exposure pathways (as identified in the site conceptual exposure model). Risks from multiple exposure pathways should be summed for a given receptor specific to each recommended exposure scenario. That is, risks should be summed across the receptor-exposure pathway combinations that are identified in the site conceptual exposure model. The total risk posed to a receptor is the sum of total risks from each individual exposure pathway expressed as follows:

$$Total\ Cancer\ Risk_T = \sum_P Total\ Cancer\ Risk_P \qquad \text{Equation E-3}$$

where

Total Cancer Risk = Total cancer risk from multiple exposure pathways

E.5.2 Human Health Noncancer Effects

Standard risk assessment models assume that noncarcinogenic effects exhibit a threshold, that is, there is a level of exposure below which no adverse effects will be observed. The potential for noncarcinogenic health effects resulting from exposure to a chemical is generally assessed by (1) comparing an exposure estimate to an RfD for oral exposures, and (2) comparing an estimated chemical-specific air concentration to the RfC for direct inhalation exposures. An RfD is a daily oral intake rate that is estimated to pose no appreciable risk of adverse health effects, even to sensitive populations, over a specific exposure duration. Similarly, an RfC is an estimated daily concentration of a chemical in air, the exposure to which over a specific exposure duration poses no appreciable risk of adverse health effects, even to sensitive populations.

The comparisons of exposure estimates and HCOC-specific air concentrations to RfD and RfC values, described above, are known as hazard quotients (HQ), which are calculated as follows:

$$HQ = \frac{ADD}{RfD} \text{ or for the air pathway } HQ = \frac{C_a}{RfC} \qquad \text{Equation E-4}$$

where

HQ = Hazard quotient (unitless)
ADD = Average daily dose (mg/kg-day)
Ca = Total HCOC air concentration (mg/m^3)
RfD = Reference dose (mg/kg-day)
RfC = Reference concentration (mg/m^3)

The total noncarcinogenic hazard attributable to exposure to all HCOCs through a single exposure pathway is known as a hazard index (HI).

$$HI_P = \sum_i HQ_i \qquad \text{Equation E-5}$$

where

HI_P = Total hazard for a specific exposure pathway
HQ_i = Hazard quotient for $HCOC_i$

This summation methodology assumes that the health effects of the various HCOCs to which a receptor is exposed are additive. Specifically, this methodology is a simplification of the HI concept because it does not directly consider the portal of entry associated with each exposure pathway or the often unique toxic endpoints and toxicity mechanisms of the various HCOCs.

A receptor may be exposed to HCOCs associated with noncarcinogenic health effects through more than one exposure pathway. For the purposes of the risk assessment, it is reasonable to estimate a receptor's total hazard as the sum of the HIs for each of the exposure pathways identified in the site conceptual exposure model. Specifically, a receptor's total hazard is the sum of hazards from each individual exposure pathway, expressed as follows:

$$Total\ HI = \sum_P HI_P \qquad \text{Equation E-6}$$

where

Total HI = Total hazard from multiple exposure pathways

All total HIs exceeding the target hazard level will be further evaluated. The total HI for an exposure pathway can exceed the target hazard level as a result of the presence of either (1) one or more HCOCs with an HQ exceeding the target hazard level, or (2) the summation of several HCOC-specific HQs that are each less than the target hazard level. In the former case, the presence of at least one HCOC-specific hazard greater than the target hazard level is interpreted as indicating the potential for noncarcinogenic health effects. In the latter case, a detailed analysis is required to determine whether the potential for noncarcinogenic health effects is accurately estimated by the total HI, because the toxicological effects associated with exposure to multiple chemicals, often through different exposure pathways, may not be additive; therefore, the total HI may overestimate the potential for noncarcinogenic health effects. To address this issue, HCOC-specific hazards will be summed according to major health effects and target organs or systems. It is especially important to consider any differences related to exposure route; this process is referred to as the segregation of the HI. Technically, segregation of the HI based only on target organs or systems is a simplification of HI. Ideally, the HI should be segregated considering also the often unique mechanisms of toxicity of the various compounds to which receptors may be exposed. However, segregating the HI based on mechanisms of toxicity is beyond a screening level or initial risk evaluation approach.

The highest segregated HI resulting from this process is considered. If the segregated HI exceeds the target hazard level, there is a potential for noncarcinogenic health effects. However, if the segregated HI is less than the target hazard level, the total HI of all HCOC-specific results likely is too conservative, and noncarcinogenic health effects are not likely to result from exposure to HCOCs.

E.5.3 Ecosystem Risk Considerations

Risk-based cleanup goals will also be based on ecosystem risk considerations pursuant to the REAM Guidance (see Figure E-1). If only a single detected HCOC for which a surface water quality criteria (WQC) has been adopted by the Commonwealth of Virginia as a standard for specific use, the WQC will be the cleanup level. For single or multiple detected HCOCs with no promulgated standards, the cleanup levels will be established on a case-by case basis considering ecological "end points". An ecological end point is the physical or biological parameter characteristic of the ecosystem.

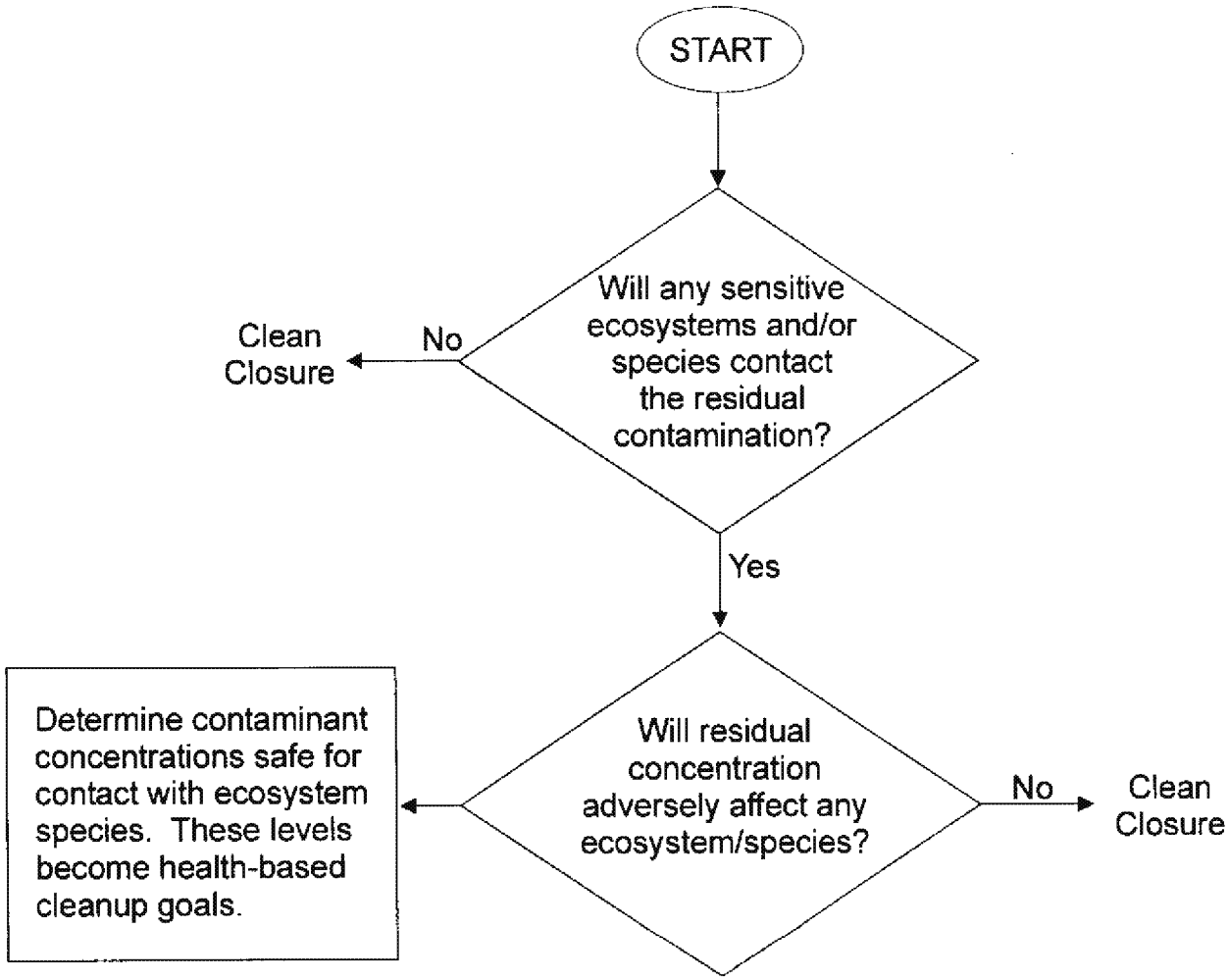

Figure E-1 Ecosystem Risk Considerations

If risk-based human health cleanup goals are not in compliance with the promulgated ecological standards, the promulgated ecological standards will be the cleanup levels.

E.6 REFERENCES

Virginia Department of Environmental Quality (VADEQ), November 1994. Guidance for Development and Submission Package for Site Remediation and Cleanup Using Health Based Standards – Risk Exposure and Analysis Modeling System (REAMs). Richmond, VA.

Virginia Department of Environmental Quality (VADEQ), June 1995. Guidelines for Developing Health-Based Cleanup Goals Closing Risk Assessment at a Hazardous Waste Site Facility for Restricted Industrial Use. Richmond, VA.

APPENDIX F

EXAMPLE CERTIFICATION OF CLOSURE

APPENDIX F

EXAMPLE CERTIFICATION OF CLOSURE

Closure activities have been conducted in accordance with the VADEQ-approved Closure Plan, dated _____, with the exception of the variations to the approved plan addressed in Section ____ of this report. Based on the information provided in this report, the work performed at the site satisfies the closure performance standard in 9 VAC 20-60-264.B.

This statement presents the professional opinion of the undersigned that is based on knowledge, information, and belief formulated in accordance with commonly accepted procedures consistent with applicable standards of practice. This statement does not constitute a guarantee or warranty, either express or implied.

_____

Signature

_____

Title

_____

Date

I hereby certify that based on my inquiry of the person or persons who manage the work, or those persons directly responsible for gathering information, the information submitted is to the best of my knowledge and belief true, accurate, and complete, and the site has been closed in accordance with the approved Closure Plan.

_____

Signature

_____

Title

_____

Date

APPENDIX G

LANDFILL CAP TESTING METHODS

APPENDIX G-1

LANDFILL CAP TESTING METHODS

1. ASTM D2922 is a nuclear method and ASTM D2937 is a drive cylinder method.

2. At least one test should be performed each day soil is compacted and additional tests should be performed in areas for which QA personnel have reason to suspect inadequate compaction.

3. Every 20th sample tested with ASTM D2922 or ASTM D2937 will be tested (as close as possible to the same test location) with the sand cone (ASTM D1556) or balloon method (ASTM D2167) to aid in identifying any systematic calibration errors with ASTM D2922 or ASTM 2937. Methods ASTM D1556 and ASTM D2167 may be used in lieu of ASTM D2922 and ASTM D2937.

4. ASTM D3017 is a nuclear method and ASTM D4643 is microwave oven drying.

5. Every 10th sample tested with ASTM D3017 or ASTM D4643 will be also tested by direct oven drying (ASTM D2216) to aid in identifying any significant, systematic calibration errors with ASTM D3017 or ASTM D4643.

APPENDIX H

POST-CLOSURE CARE INSPECTION CHECKLIST

APPENDIX H

POST-CLOSURE CARE INSPECTION CHECKLIST

Item	Type of Problem	Status
Cap	a. Uniformity of Surface b. Any visible damage c. Imperfections, holes, cracks, thin, spots, foreign material d. Evidence of settling/subsidence e. Evidence of erosion	
Vegetation	a. General condition b. Foreign items, trees, bushes, etc.	
Groundwater Monitoring Wells	a. Any visible damage to cap, casing, annular seal, or other problems	
Survey Benchmarks	a. Integrity and free of obstructions or debris	
Fence	a. Any visible damage to fence	
Sign(s)	a. Any visible damage or obstructions	
Other Security Control Device(s)	a. Integrity and functioning	
Run-On and Run-Off Control Measures	a. Integrity b. Functioning	
Cover Drainage System	a. Integrity b. Functioning	
Leak Detection System	a. Monitoring results indicate leaks or system problems b. Integrity c. Functioning	
Leachate Collection and Removal System	a. Monitoring results indicate system problems b. Integrity c. Functioning	
Gas Venting System	a. Integrity b. Functioning	

Miscellaneous:

Inspector's Name:

Date/Time of Inspection:

Supervisor contacted when any problems are detected:

Corrective action taken:

Other remarks:

Supervisor's signature:

Note: All completed checklists will be filed by the owner/operator.